MENU BASED INTERACTIVE PROGRAMS IN HYDROLOGY

by

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C E R T I F I C A T E

This is to certify that the thesis titled " **MENU BASED INTERACTIVE PROGRAMS IN HYDROLOGY** " submitted by Shri Ramesh Kumar , in partial fulfilment of the requirements for the degree of Master of Technology of the Indian Institute of Technology, Kanpur, is a bonafide research work carried out by him under my supervision and guidance. The work embodied in this thesis has not been submitted elsewhere for a degree.

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Ramesh kumar

to

my parents

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LIST OF SYMBOLS

a	Coefficient (in Eq. 4.2)
b	Coefficient (in Eq. 4.2)
Cv	Coefficient of variation
Cs	Coefficient of skewness
D	Time interval
DSRO	Direct surface runoff
e	Constant representing guage reading
E	Model efficiency (in Eq. 4.1a)
EBS	Abstraction
F_o	Sum of the squares of the differences between observed and mean discharge (in Eq. 4.1a)
F_1	Sum of the squares of the differences between observed and computed discharge
h	Unit hydrograph ordinate vector (in Eq. 4.3)
I	Incomplete gamma function (in Eq.4.5)
I	Effective rainfall ,vector,matrix,index
IALT	Dummey parameter
k	Number of rainfall blocks (in Eq. 4.8)
K	Parameter of nash model
n	Number of rainfall excess ordinates (in eq. 4.6)
n	number of runoff intervals (in Eq.4.7)
N	sample size(in Eq. 3.1)
N	Parameter of Nash model (in Eq. 4.5)
NPT	Number of points for defining class intervals
P	Rainfall
Q_o	Observed discharge (in Eq. 4.1b)
Q_c	Computed discharge (in Eq. 4.1b)
$\bar{Q}$	Mean of observed discharge (in Eq. 4.1b)
Q	Direct surface runoff vector
Q	Output vector (in Eq.4.11)
$\bar{x}$	Mean (in Eq. 3.1)
x_i	Sample values (in Eq. 3.1)
s_x	Standard deviation (in Eq. 3.2)

Se(x)	Standard error of mean
$Se(\sigma_x)$	Standard error of standard deviation
Se(Cs)	Standard error of skewness
S	Stotrage
SUMP	Cumulative rainfall
SUMQ	Cumulative DSRO
SUMX	Cumulative effective rainfall
SUMS	Cumulative storage
SEBS	Cumulative abstraction
U	System transfer matrix (in Eq. 4.11)
UH	Unit hydrograph
X	Effective rainfall
Y	Pearson Type III transformed series (in Eq. 3.8)
Y	Log transformed series (in Eq. 3.9)
z_i	Standard normal random variable
μ	Mean
σ	Standard deviation
χ^2	Chi-square statistic
ν	Degrees of freedom

ABSTRACT

A computer program has a number of steps and one may have to use them iteratively, so interactive programs are more useful, powerful and user friendly. There are various interaction styles. Menu selection is one of them. Menu selection systems are attractive because they can eliminate training and memorisation of complex command sequences. Menu selection applications range from trival choices between two items to complex videotex systems. Pop up or pull down menus appear on the screen in response to a click with a pointing device such as a mouse. Mouse is used to select the options given in the menu.

Truemouse is a software developed to use with PC mouse or Microsoft mouse. Truemouse was developed to enhance the basic mouse functions.

An approach to menu based interactive program in hydrology and water resources is illustrated with two examples using Truemouse software. In the present study, Frequency analysis and Unit Hydrograph analysis program have been developed to demonstrate the use of 'TRUEMOUSE' software through menus developed to perform various steps in the respective programs.

The software is found to be very much useful in performing the various steps involved in the execution of a program. Thus menu based interactive program is easy to use, versatile and user-friendly.

CHAPTER 1

INTRODUCTION

1.1 General

The invention of computers provided an easier way to solve many problems in Hydrology and Water Resources with greater accuracy and detail. The first electronic computer designed in 1945 by Ec Kert and Mauckly and named as ENIAC was used for solving, the then number crunching jobs. There are two aspects to the subsequent development of computers, viz, the capability, i.e., the speed of calculations, memory size, storage capacity etc. of the computer became larger and larger, and at the same time the size of the computer smaller and smaller because of miniaturization, for e.g., minis and micros. The manufacture of personal computers (PCs) by IBM MACINTOSH etc. made computers cheap, so that each person at least in the West can have his or her own computer. The present day PC is as fast as a main computer of a decade ago. Higher speeds, greater accuracy, less power consumption and privacy attracted the users to PCs. The extensive use of PCs with captive storage and graphic capabilities as well as the development of a large variety of computer networks including Local Area Networks (LAN) lead to the development of a large variety of specialised software particularly oriented to use in PCs perhaps in combination with larger systems. They include software for numerical analysis, statistical analysis, graphics and image

processing, video games, simulation, data processing, DBMS, word processing, CAD, etc. Frustation and anxiety are part of daily life for many users of computerised information systems. They struggle to learn command language, other programming languages and even some menu selection systems that are supposed to help them do their job. Researchers have shown that redesign of the human-computer interface can make a substantial difference in learning time, performance speed, error rates, and user satisfaction. Programmers and quality assurance teams are becoming more cautious and are paying greater attention to the implementation issues that guarantee high quality user interfaces.

A program has a number of steps and one may have to use them iteratively. So interactive programs are more useful, powerful and user-friendly. Marshall Mcluhan (1967) observed that "the medium is the message". Designers send a message to the users by the design of interactive systems. Great excitement exists as designers provide remarkable functions in simple and elegant interactive systems.

1.2. MENU

There are various interaction styles, viz., menu selection, form fill in, command language, natural language and direct manipulation. Only menu selection is considered here.

1.2.1 SINGLE MENU

In some situations, a single menu is sufficient to accomplish a task. Single menus may have two or more items, may require two or more screens, or may allow multiple selections. Single menus may pop up on the current work area or may be permanently available (in a separate window or on a data table) while the main display is changed. Different guidelines apply for each situation. Binary menus, multiple item menus, extended menus, pop up menus, permanent menus, and multiple selection menus come under this category. Pop-up or pull down menus appear on the screen in response to a click with a pointing device such as a mouse.

1.3 POINTING DEVICES

When a screen is used to display information, such as in air traffic control, text editing, and computer-aided design, it is often convenient to point at and/or select an item. This direct manipulation approach is attractive because the users can avoid committing to memory commands, reduce the chance of typographic errors on a key board, and keep their attention on the dispaly. The results are often faster performance, fewer errors, easier learning and higher satisfaction.

A. DIFFERENT POINTING DEVICES:

Pointing devices can be grouped into those that offer:

(i) direct control on the screen surface

a. lightpens

b. touchscreens

(ii) indirect control away from the screen surface.

a. mouse

b. trackball

c. joystick

d. graphics tablet etc.

B. POINTING TASKS :

Pointing devices are applicable in six types of interaction tasks:

(i) SELECT: The user chooses from a set of items. This may be menu selection, identification of a file in a directory, etc.

(ii) POSITION: The user chooses a point in a one, two, three or higher dimensional space. Positioning may be used to create a drawing, place a new window, or drag a block of text in a figure.

(iii) ORIENT: The user chooses a direction in a two, or higher dimensional space. The direction may simply rotate a symbol on the screen.

(iv) PATH: The user rapidly performs a series of "position" and "orient" operations.

(v) QUANTITY: The user specifics a numeric value.

(vi) TEXT: The user enters, moves, and edits text in a two dimensional space. The pointing device indicates the location of an insertion, deletion, or change.

It is possible to perform all these tasks with a keyboard.

1.3.1 DIRECT POINTING DEVICES:

The lightpen was an early device that enabled users to point to a spot on a screen and perform a select, position or other task. Touchscreen does not require picking up some device, but allows direct control touches on the screen using a finger.

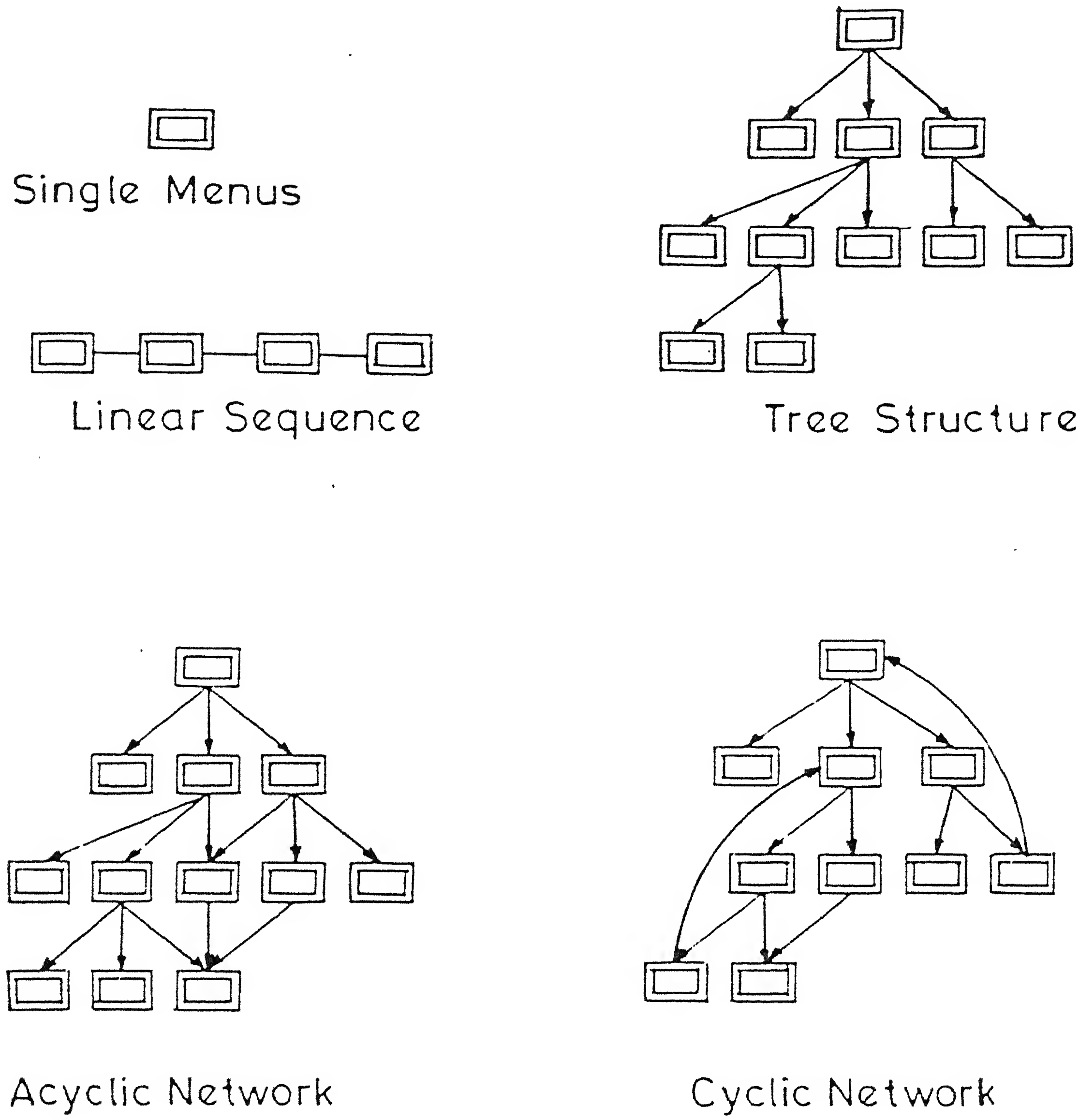
1.3.2. INDIRECT POINTING DEVICES:

Indirect pointing devices eliminate hand-fatigue and hand-obscuring the screen problems but must overcome the problem of nondirect control. Indirect control devices require more cognitive processing and hand-eye coordination to bring the onscreen cursor to the desired target.

The mouse concept is appealing (Lu, 1984) because the hand rests in a comfortable position, buttons on the mouse

Menu selection systems are attractive, because they can eliminate training and memorisation of complex command sequences. When the menu items are written using familiar terminology, users can select an item easily and indicate their choice with one or two key presses or use of a pointing device. This simplified interaction style reduces the possibility of keying errors and structures the task to guide the novice and intermittent user. The users read a list of items, select the one most appropriate to their task, initiate the action and observe the effect. If the terminology and meaning of the items are understandable and distinct, then the users can accomplish their task with little learning or memorisation and few key strokes. The greatest benefit may be that there is a clear structure to decision making since only a few choices are presented at a time.

Menu selection applications (Fig. 1.1) range from trivial choices between two items to complex videotex system with 300,000 screens. The simplest applications consist of a single menu, but even with this limitation there are many variations. The second group of applications includes a linear sequence of menu selections; the progression of menus is independent of the user's choice. Strict tree structures make up the third group, which is the most common situation. Acyclic (menus which are reachable by more than one path) and cyclic (menus with meaningful paths that allow users to repeat menus) networks constitute the fourth group.



FIG·1·1 MENU STRUCTURES
(From Designing the User Interface
by Ben Shneiderman, 1986)

are easily pressed, even long motions can be rapid, and positioning can be very precise. However, the mouse must be picked up to begin work, desk space is consumed, the mouse wire can be distracting, pickup and replace actions are necessory for long motions, and some practice is required to develop skill.

The trackball concept has sometimes been described as an upside down mouse. It is implemented as a rotating ball two to six inches in diameter that moves a cursor on the screen as the ball is moved.

The joystick concept came as automobile and aircraft control devices. Joysticks are appealing for tracking purposes, i.e., to follow a moving object on a screen, in part because of the relatively small displacements necessary to move a cursor and the ease of direction changes.

The graphics tablet concept is to have a touch sensitive surface separate from the screen, usually flat on the table or in the user's lap. This allows for a comfortable hand position and keeps the users' hands off the screen.

1.4 SELECTION OF POINTING DEVICE FOR MENU MAKING

Due to the availability of the menu-maker software 'TRUEMOUSE' along with mouse, mouse has been chosen as pointing device.

1.5 OBJECTIVES OF THE STUDY

The main objective of the study is to study and illustrate the capability of interactive programs and to develop menu based interactive programs to demonstrate these capabilities.

1.6 SCOPE OF THE STUDY

Though there are many menu building software, because of the availability of the TRUEMOUSE, it is proposed to use this software in the present study. A limited number of programs have been developed to demonstrate its use, viz., Frequency analysis program and Unit Hydrograph analysis program.

1.7 ORGANISATION OF THE STUDY

The present study is reported as follows -

1. Introduction to menubased interactive programs and their development through menu building softare are reported in Chap. 1.
2. A brief description of Truemouse software, its operation and its use in this study are reported in Chap. 2.
3. Development of a menubased interactive program using the menu making capabilities of Truemouse software for frequency analysis and its application is reported in Chap. 3.

4. Development of a menubased interactive program using the menu making capabilities of Truemouse software for unit hydrograph and its application is reported in Chap. 4.

5. Summary, conclusions and suggestions for future work are reported in Chap. 5.

CHAPTER - 2

TRUEMOUSE SOFTWARE

2.1 INTRODUCTION:

The mouse is a hand held device. It can thus be used as a pointing device that provides a user-friendly interface for all computer applications. The mouse concept is appealing because the hand rests in a comfrotable position, buttons on the mouse are easily pressed, even long motions can be rapid, and positioning can be very precise. It has two or three buttons and is moved on a surface to move the cursor on the screen. With its speed, accurary and simplicity the mouse has become an indispensible part in the work environment of computers. It also facilitates user interaction during program execution.

Operation of the mouse is mainly based on the movement of the cursor and selection of an object or a command of interest. Cursor movement or selection can be done by using either keyboard or mouse.

User can use four arrow keys to move the cursor. The cursor is moved from item to item instead of from character to character except if it is in a selected object. Selection is done by placing the cursor in the object of interest and pressing the RETURN Key.

The cursor moves character by character according to the mouse movement. Selection is made by pressing one mouse button. The Keyboard can also be used at the same time. The mouse is a more 'direct' tool to locate the cursor on the item of interest quickly.

A mouse generally provides the following functions:

1. CLICKING FUNCTION: Clicking of mouse buttons is required to make a selection,
2. CURSOR MOVEMENT CONTROL: To replace the very rigid cursor control on the key board and,
3. GRAPHIC APPLICATION: To draw easily various lines, arcs, circles, polygons, squares and so on.

Truemouse is a software developed by True Dox Technology Corporation to use with PC-mouse or Microsoft mouse. Model TX 3000 has been used in the study. Truemouse was developed to enhance the basic mouse functions:

a. More accurate and responsive cursor control
b. Distortion free drawing ability
c. Complete compatibility with the major mouse systems currently available, and
d. Dynamic resolution

Truemouse Provides full support for advanced applications:

a. Truemouse driver support with complete technical documentation.

b. complete set of commands; generates various mouse working modes for advanced programming; and

c. pop-up menu compiler suport.

2.2 COMPATIBILITY:

Table 2.1 gives the hardware compatibility list (Truemouse User's Manual)

Table 2.1. Hardware compatibility list

Mouse mode	Tx 300	Tx 3000	Ps 4000	Ps 401
Microsoft serial Mouse	yes (default)	yes (default)	yes (default)	yes
PC Mouse	yes	yes	yes	no
PS/2 Mouse	no	no	yes (default)	yes (default)

TRUEMOUSE driver provides a unique function for hardware compatibility. AUTO-SWITCHING COMPATIBILITY, which is to let your mouse work directly as either Microsoft serial mouse or PC mouse without any mouse mode presetting- just simply load the TRUEMOUSE driver and run the program. This means that when TRUEMOUSE is used with mouse-based

application software (e.g. Auto CAD, MS Windows etc.) the PC mouse mode or Microsoft serial mouse mode may be chosen. Then the TRUEMOUSE will automatically switch to that particular mouse mode and work with the application program.

b. Software compatibility: Truemouse driver is fully compatible with the industry standards, Microsoft serial mouse driver and PC mouse driver. One can use TRUEMOUSE with its driver to run all the programs that need Microsoft driver or PC mouse driver as the interface.

2.2.1 SYSTEM REQUIREMENT:

One must have atteast one of the items in each of the following categories in order to run the TRUEMOUSE.

1. Personal Computer

   IBM PC, PC/XT, PC/AT, PS/2 or 100% compatible, which contains:

   a. 1 disk drive, 2 disk drives, or hard disk.

   b. 256K of RAM

   c. RS- 232 C Serial Interface card (for serial mouse)

2. DISPLAY ADAPTOR:

   a. IBM colour graphics Adapter, or

   b. IBM Monochrome Display Adapter, or

   c. IBM Enhanced Graphics Adapter, or

   d. Hercules Monochrome Graphics Adapter

2.3. INSTALLING THE MOUSE:

This section provides instructions for installing the mouse handware and software.

a. HARDWARE INSTALLATION:

1. Turn off computer
2. Locate a RS-232 C port (com 1 or com 2) or PS/2 mouse port on the rear panel of computer.
3. Insert the mouse connector of the mouse into the mouse port. Then tighten the screws on the mouse connector.

b. SOFTWARE INSTALLATION:

1. Using TRUEMOUSE with non-mouse based software

a. Install the TRUEMOUSE driver -

Filename : TRUEMOUSE. COM

b. Use setup utility to set TRUEMOUSE into PC Mouse mode to activate all 3 buttons of mouse:

FILENAME : SETUP. COM

c. Switch on the Pop-up menu by file MENU-EXE

Example : MENU TRU - <FREQ>

The Pop-up menu is ready after the 'MENU ON' message appears on the screen.

Start the application program now the mouse can handle most of commands for which one previously used the keyboard to do the jobs.

2. Using TRUEMOUSE with mouse based software

a. Install the TRUEMOUSE driver -

Filename : TRUEMOUSE

b. When driver installation is compute message appears, then use software package.

C > <Filename>

2.4 TRUEMOUSE PACKAGE CONTENTS:

Truemouse package contents are given in the Table 2.2

2.5 CREATING POP-UP MENU FOR NON-MOUSE BASED APPLICATIONS:

TRUEMOUSE software is designed to make pop-up menu for non-mouse based applications. To create pop-up menu one must proceed according to the following steps:

1. Use word processor or Editor which is compatible with DOC text file format (e.g. PE 2, Professional Editor, Word Star, word perfect, etc.) to create a menu source file, with an extension name of DEF.

2. Use Menumaker compiler file:

MAKEMNU. EXE to compile source file

[SYNTAX] : Makemnu filename <ENTER>

2.5.1 MENU LANGUAGE STATEMENTS:

Commands which assign different functions to generate pop-up menu are needed to work with the mouse. TRUEMOUSE menu maker has differrent commands to do the job. A set of

TABLE 2.2 Truemouse Package Contents
(From Truemouse user manual)

MODEL No.	TX300	TX3000	PS4000	PS401
Mouse Module	Yes	Yes	Yes	Yes
User's Manual	Yes	Yes	Yes	Yes
Programmer's & Compiler's Manual	No	Yes	Yes	Yes
Mouse Pad	Yes	Yes	Yes	Yes
Mouse Pocket	Yes	Yes	Yes	Yes
SYSTEM FLOPPY:				
Truemouse driver	Yes	Yes	Yes	Yes
Menu Library	Yes	Yes	Yes	Yes
Menu Compiler	No	Yes	Yes	Yes
Source files	No	Yes	Yes	Yes
Demo Program	Yes	Yes	Yes	Yes
Test Program	Yes	Yes	Yes	Yes
Install Utility	No	Yes	Yes	Yes
• README.DOC	Yes	Yes	Yes	Yes

statements constitute the program. Different commands, command descriptions, statement format and error messages of TRUEMOUSE are given in appendix A.

2.6 TRUEMOUSE APPLICATIONS IN WATER RESOURSES:

TRUEMOUSE is designed to make single or multiple column pop-up menu for converting non-mouse based applications to mouse based interactive applications. The TRUEMOUSE provides the compatibility with the non-mouse based application programs. Hence TRUEMOUSE can also be used in Water Resources. One can make programs menu based and the functions and controls which were done earlier using keyboard, can now be done with the help of mouse. In this study, two programs, i.e., Frequency analysis program and Unit Hydrograph analysis program are done menu based. Separate menus are prepared for Frequency analysis and Unit Hydrograph methods. One can go to the main menu and from there one can select the required option.

These examples are used to illustrate the advantages of menu based interactive applications in Hydrology and Water Resources.

CHAPTER - 3

MENU BASED FREQUENCY ANALYSIS PROGRAM

3.1 INTRODUCTION

Hydrologic processes evolve in space and time in a manner that is partly predictable, or deterministic, and partly random. Such a process is called stochastic or probabilistic process. So a stochastic or 'probabilistic' model is one involving random variables having distributions in probability and whose outputs are predictable only in a statistical sense.

Hydrologic events are sometimes impacted by extreme events, such as severe storms, floods and droughts. The magnitude of an extreme event is inversly related to its frequency of occurance, very severe events occuring less frequently than more moderate events. The objective of frequency analysis of hydrologic data is to relate the magnitude of extreme events to their frequency of occurance through the use of probability distribution. "RISK" may be defined as exposure to an undesirable event. 'Probability' is a measure of risk.

The basic objective in the use of statistical methods and statistical distributions is the analysis of outcomes of real observations of random phenomena. In the process of

solving practical statistical problems. The following steps are generally required:

i. Selection of a statistical distribution

ii. Estimation of its parameter

iii. Testing the goodness of fit

iv. Prediction of floods with specified frequency using the fitted distribution.

3.2 TERMINOLOGY:

i. Population: It encompasses all possible values an event can take.

ii. Sample data: Sample data are the available data from the observations of a process in terms of the value of the variable characteristics.

iii. Random Sample: A random sample is taken from the population in such a way that every possible sample, drawn in a specified manner, has an equal chance of being chosen.

iv. Recurrence Interval: T years recurrance interval or return period means an event which may be equalled or exceeded, on an average, once in T years.

vi. Standard error of estimate: It is a measure of the standard deviation of event magnitudes computed form samples about the true event magnitude .

vii. Mean: It is a measure of central tendency of the data and is given by

$$\bar{x} = \frac{1}{N} \sum_{i=1}^{N} x_i \qquad \text{(Eq. 3.1)}$$

where x_i, $i = 1,2.........N$, represents N sample values and N is the sample size.

viii. Standard deviation: Standard deviation is a measure of the variability of the data series about the mean. The unbiased estimate of the standard deviation is given by:

$$s_x = \left(\sum_{i=1}^{N} (x_i-\bar{x})^2 \;/\; (N-1)\right)^{1/2} \qquad \text{(Eq. 3.2)}$$

ix. Variance: Variance is the square of standard deviation.

x. Coefficient of Variation: It is a dimensionless parameter, sometimes used as a regionalisation parameter, defined as

$$C_v = s_x / \bar{x} \qquad \text{(Eq. 3.3)}$$

xi. Coefficient of skewness: It is a measure of the symmetry of the empirical distribution of the sample data. The unbiased estimate of the coefficient of skewness is given by

$$C_s = \frac{N \sum_{N=1}^{N} (x_i - \bar{x})^3}{(N-1)\,(N-2)\, s_x^{3}} \qquad \text{(Eq. 3.4)}$$

xii. **Standard error of statistical parameters:** The statistical parameter such as mean, standard deviation, co-efficient of skewness calculated from the data (or sample) are not the true values of the population parameters. The standard errors associated with these parameters are given by equations:

$$S_e(x) = \sigma x / \sqrt{N} \qquad \text{(Eq. 3.5)}$$

$$S_e(\ \ x) = \sigma x / \sqrt{2N} \qquad \text{(Eq. 3.6)}$$

$$S_e(C_s) = 6N(N-1)/((N-2)(N+1)(N+3)) \qquad \text{(Eq. 3.}$$

with $S_e(x)$, $S_e(\sigma x)$ and $S_e(C_s)$ being respectively the standard errors of mean, standard deviation and co-efficient of skewness.

3.3. STRUCTURE OF THE MENU BASED PROGRAM

The structure of the program is as follows:

i. The program sorts out the data for a particular season. In the case of time series of monthly data the program sorts out the data for each month while in the case of weekly data, the data for each week are separated.

ii. The program arranges the seasonal data in descending order.

iii. Now depending upon the user's option, the various transformations may be applied to the ordered data.

When data are such that they need complex probability distributions and fitting these distributions is difficult, one transforms the data into a simpler form using one or more transformations. Generally transformations are used to normalise the data so that they have a near Normal or Gaussian distribution.

3.3.1. INTERACTIVE PROGRAM (NON MOUSE BASED)

A. MAIN PROGRAM

A noninteractive computer program written in Fortran language for frequency analysis was available for the study. The program was modified in terms of the subroutines and interaction particularly in the main program. User gives the choice of the distribution and according to one's choice various subroutine programmes are called to fit a distribution.

B. SUBROUTINES

Different subroutines are written for different transformations. The subroutines are as follows:

1. IPT

This subroutine uses the following equation (Wilson-Hilferty Transformation) to normalise the data assumed to be originally Gamma distributed.

$$Y = \left[\left(\frac{(C_s)}{2} \left(\frac{x-\mu}{\sigma} \right) + 1 \right)^{1/3} - 1 \right] \frac{6}{C_s} + \frac{C_s}{6} \qquad \text{(Eq. 3.8)}$$

where:

x : Original series

μ : Mean of the original series

σ : Standard deviation of original series

C_s : Co-efficient of skewness of original series

Y : Pearson type III transformed series

2. LOGTRAN

This subroutine converts the original series into log transformed series.

$$Y = \text{Log } x \qquad \text{(Eq. 3.9)}$$

Y : Log transformed series

x : Original Series

3. LT

This subroutine is used for Log Normal distribution. Parameters of the log transformed seris are calculated on the basis of following theoretical relationships:

$$\mu_y = \log(\mu_x) - 0.5 \log \{(\sigma_x / \mu_x)^2 + 1\} \qquad \text{(Eq. 3.10)}$$

$$\sigma_y = \{\log ((\sigma_x / \mu_x)^2 + 1)\}^{1/2} \qquad \text{(Eq. 3.11)}$$

where:

μ_y : Mean of log transformed series

σ_y : Standard deviation of the log transformed series

4. SQTRAN

This subroutine takes the square root of the original series to transform the original series.

5. PARA

This subroutine calculates the various statistical parameters, viz., mean, standard deviation and skewness of the data given.

6. CHISQRT

The subroutine computes χ^2 statistic and the degrees of freedom.

The goodness of fit of a probability distribution can be tested by comparing the theoretical and sample values of the relative frequency or the cumulative frequency function. In the case of relative frequency function, the ^{2} test is used.

To describe the χ^2 test, the χ^2 probability distribution must be defined. A χ^2 distribution with ν degrees of freedom is the distribution for the sum of squares of independent standard normal random variables z_i, this sum is the random variable.

$$\chi^2 = \sum_{i=1}^{\nu} z_i^2 \qquad \text{(Eq. 3.12)}$$

In χ^2 test, ν = m-p-1, m is the number of class intervals, and p is the number of parameters used in fitting the proposed distribution .

7. CDFN

This subroutine calculates cummulative frequency function for normal distribution with mean μ and standard deviation σ.

8. STVAR

This subroutine calculates standard normal variate corresponding to a given probability.

9. SSORT

This subroutine arranges the data in the descending order.

10. WRIT

This subroutine writes the values of statistical parameters, viz., mean, standard deviation, skewness of different seasonal data.

3.4 DEVELOPMENT OF MENU BASED PROGRAM

A program is written to develop pop-up menu for Frequency analysis. Program is developed in the following way:

(i) All the mouse parameters have been defined using BEGIN statement as given in Appendix A.

(ii) A main menu has been prepared in which various options for sub menus are given. Main menu has been developed using the 'MENU' command. The syntax is given in Appendix A. (iii) Options of Main menu are sub menus or commands. sub menus are as follows:

a. INSTRUCTIONS

Instructions are given in this sub menu for the user. This submenu appears on the screen when the user brings the cursor to the 'Instruction' option of the Main menu and clicks the mouse left button.

```
=============== INSTRUCTIONS ====================
IF YOU WANT YOUR RESULTS TO COME IN NEW FILE
THEN YOU HAVE TO RENAME YOUR FIRST OUTPUT FILE
OTHERWISE ALL RESULTS WILL COME IN SINGLE FILE
=================================================
```

b. PROBABILITY DISTRIBUTIONS

This sub menu appears on the screen when the user clicks the left mouse button after bringing the cursor to the 'Probability Distribution' option in the Main menu. This sub menu contains the various probability distributions, and their output file names. User can choose respective output files for different probability distributions for their output.

This pop-up sub menu also has the option to terminate the execution of the program and to go to the main menu.

```
========================POP-UP MENU==============================
|DISTRIBUTION TYPE            OUTPUT FILES        VIEW OUTPUT FILES
 NORMAL DISTRIBUTION            NORMD.OUT            NORMD.OUT
|INVERSE PEARSON TRANS          INPDS.OUT            INPDS.OUT
 SQUAREROOT TRANS               SQRTE.OUT            SQRTE.OUT
|LOG NORMAL DIS(MLE)            LOGNR.OUT            LOGNR.OUT
 PEARSION DISTRIBUTION          PEARS.OUT            PEARS.OUT
|LOG TRANSFORMATION(MOM)        LOGTR.OUT            LOGTR.OUT
|-----------------------------------------------------------------
|STOP THE PROGRAM               MAIN MENU
=================================================================
```

Details for writing the menu making program is given in Appendix A.

Listing of the menu making program is given in Appendix B.

3.5 APPLICATIONS

3.5.1. SYSTEM

The pop-up menu has been developed on PC/XT. Application program has been run on the same system.

3.5.2 INITIAL START UP

To start the application of the program, one has to open an input file. Input file contains:

i. Name of the program.

ii. Total number of data values, number of seasons, NPT, IALT

iii. Actual Data

If input file satisfies the above requirements, invoke the truemouse software for application. To execute the pop-up menu for the Frequency analysis program, use menu maker execution file MENU FREQ. Now MENU ON ! message appears- on the screen and pop-up menu is ready to use. Now run the FREQ. FOR program with the help of mouse.

3.5.3. **ANALYSIS AND DISCUSSION OF RESULT:**

The input file named STREAM.DAT has been opened. The data are given for 17 years. Input Data (monthly data for 17 years) are given in Table 3.1. Seasonal analysis of the given data is done using the FREQ. FOR program using the menus. Various distributions are fitted to the given data to see which distribution fits the data best.

The seasonal averages, seasonal standard deviations, seasonal coefficient of skewness, chi square statistic, and number of degrees of freedom have been computed for the given sesonal values applying different probability distributions.

The χ^2 statistic for different distributions for various months are tabulated in Table 3.2.

It may be noted that the theoretical χ^2 statistic for 3 degrees of freedom at 95% confidence level is 7.815. The χ^2 statistic for months of June, November, January to April are much higher indicating perhaps the effect of small

TABLE 3.1

INPUT DATA FOR FREQUENCY ANALYSIS PROGRAM

```
FREQUENCY ANALYSIS OF STREAMFLOW DATA
2Ø4 12 7 1
1.8Ø   1.8Ø   1.8Ø 1.8Ø 1.8Ø 1.8Ø 1.8Ø 1.8Ø 1.8Ø 1.8Ø 1.8Ø 1.8Ø
8.91  13.35  13.13 2.46 1.55 Ø.76 Ø.45 Ø.31 Ø.25 Ø.15 Ø.11 Ø.29
4.46   7.97  13.11 3.78 1.29 Ø.49 Ø.28 Ø.21 Ø.26 Ø.16 Ø.13 Ø.15
4.87  1Ø.81   7.94 1.17 Ø.5Ø Ø.33 Ø.31 Ø.2Ø Ø.17 Ø.31 Ø.13 Ø.28
1.77   7.Ø6   1.47 1.16 Ø.42 Ø.26 Ø.2Ø Ø.14 Ø.13 Ø.Ø8 Ø.Ø6 Ø.44
4.42  12.88   4.8Ø Ø.83 Ø.34 Ø.24 Ø.21 Ø.15 Ø.13 Ø.Ø8 Ø.Ø6 Ø.Ø7
4.95  13.92   4.21 Ø.97 Ø.38 Ø.28 Ø.2Ø Ø.14 Ø.Ø9 Ø.Ø7 Ø.Ø6 Ø.12
3.27   5.69  14.88 2.63 Ø.83 Ø.41 Ø.26 Ø.18 Ø.1Ø Ø.Ø7 Ø.Ø5 Ø.59
2.53  1Ø.63  18.36 7.Ø1 1.17 Ø.55 Ø.35 Ø.23 Ø.17 Ø.12 Ø.Ø9 Ø.91
11.86 14.21   7.64 2.88 1.81 Ø.67 Ø.58 Ø.34 Ø.31 Ø.3Ø Ø.14 Ø.5Ø
3.22   9.65   5.47 Ø.93 Ø.43 Ø.28 Ø.22 Ø.16 Ø.17 Ø.Ø9 Ø.Ø7 Ø.21
4.61   7.77   9.72 4.24 1.21 Ø.49 Ø.31 Ø.22 Ø.16 Ø.1Ø Ø.71 Ø.16
11.ØØ 16.34  15.63 3.36 1.ØØ Ø.51 Ø.52 Ø.29 Ø.23 Ø.18 Ø.2Ø Ø.26
4.34  16.68   3.11 2.54 Ø.74 Ø.49 Ø.34 Ø.29 Ø.18 Ø.13 Ø.1Ø Ø.6Ø
1Ø.28 12.12  25.32 6.63 1.41 Ø.76 Ø.53 Ø.36 Ø.29 Ø.22 Ø.14 Ø.11
3.13   5.52  12.19 1.64 Ø.66 Ø.77 Ø.36 Ø.23 Ø.19 Ø.12 Ø.Ø8 Ø.25
1.88   9.78   9.71 1.31 Ø.53 Ø.35 Ø.24 Ø.18 Ø.17 Ø.1Ø Ø.Ø8 Ø.4Ø
8.58   9.35   5.95 2.22 Ø.62 Ø.36 Ø.27 Ø.15 Ø.13 Ø.11 Ø.Ø7 Ø.17
```

TABLE 3.2

Theoretical Chi square value χ^2(95% , 3DOF) = 7.815

χ^2- values for different distributions

Month	Normal Dist.	Sqrt. Transform.	Pearson Dist.	Log Pearson Dist.	Log Normal (MOM).
June	10.877	47.640	10.877	90.403	10.877
July	2.626	78.400	2.626	90.403	4.127
August	2.626	57.395	2.626	90.403	1.880
September	8.622	19.884	8.622	67.896	3.383
October	2.629	15.379	2.629	22.828	4.134
November	13.121	31.926	13.121	31.121	7.872
December	16.121	39.436	16.121	42.371	7.121
January	32.621	49.197	32.621	78.371	17.621
February	39.371	49.197	39.371	78.371	14.621
March	57.371	42.436	57.371	78.371	11.621
April	57.371	40.936	57.371	56.621	9.371
May	12.371	24.417	12.371	37.121	4.126

Parameters of Fitted Distribution
(Log Normal Distribution)

Month	Average	Standard Deviation	Co-efficient of Skewness
July	4.127	.378	-.312
August	2.118	.593	.737
Septenber	.780	.634	1.314
October	-.181	.499	.439
December	-1.157	.764	3.453
May	-1.212	.830	2.516

samples size, viz., 17 values in five classes give around 3 value per class on average as against five value per class recommended for the analysis. For July and October, normal distribution and for August, September, December and May log normal distribution indicate the minimum χ^2 value. However for the month of July and October, χ^2 values for log normal distribution indicate a good fit at 95% confidence level. Hence for consistency among the seasons a log normal distribution can be considered to be good fit in the monsoon months of July to October, December and also for May. No distribution is found to fit for other months at 95% confidence level.

Parameters of fitted distribution are shown in Table 3.2. Analysis results are shown in Table 3.3.

3.5.4. CONCLUSION

Use of pop up menu for interactive program makes the execution of the program simple. Here one has not to remember the different options. Different options appear on the screen in the form of pop-up menu with the help of mouse. One has to select the desired option.

Thus the use of menu based interactive program along with mouse makes the execution of the program easy.

TABLE3.3 FREQUENCY ANALYSIS OF STREAMFLOW DATA

TOTAL NUMBER OF VALUES= 204
NO. OF SEASONS PER YEAR= 12
NFT= 7

ANALYSIS FOR NORMAL DISTRIBUTION
****

SEASONAL AVERAGES
****

5.135	10.364	9.911	2.667	.945	.555	.421	.319	.282	.240	.276	.408

SEASONAL STANDARD DEVIATION
****

3.291	4.066	6.436	1.876	.502	.367	.375	.388	.396	.409	.431	.418

SEASONAL COEFFICIENT OF SKEWNESS
****

1.084	-.312	.737	1.314	.439	2.620	3.453	3.906	3.952	3.906	3.438	2.516

CHI-SQUARE STATISTIC
****

10.877	2.626	2.626	8.622	2.629	13.121	16.121	32.621	39.371	57.371	57.371	12.371

NO. OF DEGREES OF FREEDOM
****

3	3	3	3	3	3	3	3	3	3	3	3

INVERSE PEARSON TRANSFORMATION
****

SEASONAL AVERAGES
****

.028	-.003	.010	.037	.006	-.124	.142	.408	.419	.423	.345	.014

SEASONAL STANDARD DEVIATION
****

.931	.997	.985	.922	.987	1.317	.920	.556	.549	.532	.574	1.084

SEASONAL COEFFICIENT OF SKEWNESS
****

.680	-.097	.225	.655	.292	-.856	-.131	2.323	2.322	2.749	2.648	-.720

CHI-SQUARE STATISTIC
****

4.877	1.126	2.626	2.626	2.629	6.373	4.123	4.123	8.623	11.621	20.621	2.622

NO. OF DEGREES OF FREEDOM
****

3	3	3	3	3	3	3	3	3	3	3	3

SQUAREROOT TRANSFORMATION
****

SEASONAL AVERAGES
****

2.167	3.146	2.975	1.549	.939	.718	.615	.522	.481	.424	.4Ø2	.595

SEASONAL STANDARD DEVIATION
****

.684	.7Ø5	1.Ø61	.535	.261	.2Ø7	.212	.223	.233	.253	.281	.266

SEASONAL COEFFICIENT OF SKEWNESS
****

.723	-.962	.ØØ6	.784	.166	1.733	2.723	3.436	3.475	3.314	2.85Ø	1.456

CHI-SQUARE STATISTIC
****

47.64Ø	78.4ØØ	57.395	19.884	15.397	31.926	39.436	49.197	49.197	42.436	4Ø.936	24.417

NO. OF DEGREES OF FREEDOM
****

3	3	3	3	3	3	3	3	3	3	3	3

LOG TRANSFORMATION
****

SEASONAL AVERAGES
****

1.457	2.232	2.Ø42	.768	-.231	-.73Ø	-1.352	-1.4Ø4	-1.595	-1.9Ø6	-2.Ø85	-1.2Ø6

SEASONAL STANDARD DEVIATION
****

.613	.542	.8Ø5	.669	.57Ø	.514	.544	.595	.659	.792	.927	.825

SEASONAL COEFFICIENT OF SKEWNESS
****

.249	-1.837	-.722	.258	-.1Ø4	.849	1.763	2.483	2.335	2.1Ø3	1.972	.319

CHI-SQUARE STATISTIC
****

58.893	78.399	67.146	34.134	78.399	93.4Ø3	9Ø.4Ø3	9Ø.4Ø3	9Ø.4Ø3	9Ø.4Ø3	9Ø.4Ø3	9Ø.4Ø3

NO. OF DEGREES OF FREEDOM
****

3	3	3	3	3	3	3	3	3	3	3	3

LOG TRANSFORMATION
****

INVERSE PEARSON TRANSFORMATION
****

SEASONAL AVERAGES
****

.003	.007	-.010	.003	-.001	.010	.018	-.228	-.151	-.059	.055	.003

SEASONAL STANDARD DEVIATION
****

.997	1.058	.980	.997	.999	.992	.994	1.540	1.577	1.166	.927	.999

SEASONAL COEFFICIENT OF SKEWNESS
****

.108	.241	-.276	.135	-.071	.130	.120	-1.107	-1.732	-.570	.330	.048

CHI-SQUARE STATISTIC
****

90.403	90.403	30.403	67.396	22.378	31.121	42.371	73.371	78.371	78.371	56.621	37.121

NO. OF DEGREES OF FREEDOM
****

3	3	3	3	3	3	3	3	3	3	3	3

METHOD OF MOMENTS FOR LOG NORMAL DISTRIBUTION
****

SEASONAL AVERAGES
****

1.164	2.267	2.113	[illegible]	[illegible]	[illegible]	-1.157	-1.534	-1.308	-2.108	-2.178	-1.212

SEASONAL STANDARD DEVIATION
****

.587	.375	.533	.634	.433	.623	.764	.952	1.343	1.167	1.211	.830

SEASONAL COEFFICIENT OF SKEWNESS
****

1.384	-.312	.737	1.314	.439	2.623	3.453	3.306	3.952	3.906	3.438	2.516

CHI-SQUARE STATISTIC
****

13.377	4.127	1.380	3.383	4.134	7.372	7.121	17.621	14.621	11.621	9.371	4.126

NO. OF DEGREES OF FREEDOM
****

CHAPTER - 4

MENU BASED UNIT HYDROGRAPH PROGRAMS

4.1 INTRODUCTION

The estimation of flood flows resulting from the rainfall is required in the planning, design and operation of water resources projects. The unit hydrograph technique is a simple tool being used by most of the water resources development organisations in different countries for estimation of direct surface runoff. Unit hydrograph, by definition, is the direct surface runoff hydrograph that would be observed at the outlet of the drainage area as a result of unit rainfall excess falling over the catchment, with a specified distribution, say uniform in space and uniformly in time within the specified duration. The unit hydrograph technique assumes the catchment as a linear system which transforms the rainfall input into direct surface runoff as an output. It is well known that the assumption of linearity involved in the unit hydrograph technique does not accurately apply for the natural water sheds. Inspite of the assumption of linearity, analysis of field data indicates that the unit hydrograph derived from different storms are not identical and are sensitive to data errors. Inspite of its limitations, unit hydrograph is a

powerful and practical tool for predicting flood flows if it is applied with care and proper judgement.

4.2 DIFFERENT UH METHODS

Various techniques are available in the literature for deriving the unit hydrograph. Nearly all of them have some limitations. In selecting a particular technique for the derivation of unit hydrograph it is preferable to satisfy amongst others, the following requirements:

(i) The unit hydrograph ordinates are all positive.

(ii) The shape of the UH is preserved.

(iii) The errors in inpur data are not amplified during the unit hydrograph derivation.

(iv) The method is capable of admitting a number of events simultaneously for the unit hydrograph derivation.

(v) Computationally, the method is simple, efficient and easily programmable.

Each technique has its strengths and weaknesses and does not satisfy all the above requirements.

The unit hydrograph is basically a multiplier which converts the excess rainfall to direct surface runoff. Thus it can be said that the UH only deals with the direct surface runoff and excess rainfall. Therefore, the baseflow must be separated from the stream flow hydrograph and

losses must be accounted for from the average rainfall hyetograph in order to get the direct surface runoff hydrograph and excess rainfall hyetograph respectively.

4.2.1 TERMINOLOGY

(i) Unit Hydrograph: It is a hydrograph of direct surface runoff resulting from unit excess rainfall falling uniformly over the catchment in space and time for a specified duration.

(ii) Instantaneous Unit Hydrograph: It is a UH for rainfall of infinitesimally small duration.

(iii) Excess (or effetive) Rainfall: The part of the rainfall which appears over the surface as runoff and later on contributes to the stream flow of the catchment.

(iv) Base Flow: It is that contribution to a stream flow _hydrograph which results not from the rainfall, but from releases of water from essentially ground water storage.

(v) Direct Surface Runoff: It is that portion of runoff which results at the catchment outlet due to excess rainfall.

(vi) Linear Reservoir: Conceived elements in the basin in which storage is assumed to be directly proportional to the discharge.

(vii) Time of Concentration: It is the travel time of a water particle from the most upstream point in the basin to the outflow location.

(viii) Model Efficiency: The model efficiency may be mathematically defined as;

$$E = (F_0 - F_1')/\ F_0 \qquad \text{(Eq. 4.1a)}$$

$$F_0 = \sum_{i=1}^{n} (Q_0\ (i) - \bar{Q})^2 \qquad \text{(Eq. 4.1b)}$$

$$F_1' = \sum_{i=1}^{n} (Q_0\ (i) - Q_c\ (i)\ )^2 \qquad \text{(Eq. 4.1c)}$$

where, Q_0 (i) and Q_c (i) are ith values of observed and computed discharges respectively, $\bar{Q}$ is the mean of n values of observed discharges, E is the model efficiency, F_0 is the sum of the squares of the differences between observed discharges and mean discharge, and F_1' is the sum of squares of the differences between observed discharges and computed discharges using the model.

(ix) Average Standard Error: It is the root mean squared sum of differences between observed and computed hydrographs.

(x) Average Absolute Error: It is the average of the absolute values of the differences between observed and computed hydrographs.

(xi) Average Percentage Absolute Error: It is the average of the absolute values of percent differences between computed and observed hydrograph ordinates.

(xii) Percentage Absolute Error in Peak: It is the ratio of the absolute difference in observed and computed peak and observed peak.

(xiii) Percentage Absolute Error in Time to Peak: It is the ratio of the absolute difference between observed and computed time to peak and observed time to peak.

(xiv) Objective Function: It is the sum of the squares of the differences between observed and computed discharges as given in Eq.1c.

4.2.2. COMPUTATION OF DISCHARGE AND RATING CURVE ANALYSIS

(i) **Stage Discharge Relationship:**

Generally a single valued relationship between the stage and the discharge expressed in the following form is developed for those streams and rivers which exhibit permanent control:

$$Q = a(G-e)^b \qquad \text{(Eq. 4.2)}$$

where,

Q = Storm discharge (m^3/s)

G = Gauge ht or stage (m)

e = a constant which represents the gauge reading corresponding to zero discharge (m)

The best values of a and b in Eq.4.2 for a given range of stage are obtained by the least squares method.

A computer program RATING.FOR is used for developing the stage discharge curve relationship using the least squares method and making a trial and error search for the unknown constant e.

4.2.3. CONVERSION OF STAGE VALUES TO CORRESPONDING DISCHARGE VALUES:

Using the stage discharge relationship the coefficients a,b and the constant e are determined from observed stage and corresponding discharge values using least squares method (Sec. 4.2.2).

If a,b and e are known, Eq.4.2 may be used to compute the values of the discharge corresponding to the various stage values. The use of Eq.4.2 for converting the stage into discharge should, as for as possible, be avoided in the extrapolation range.

A computer program GAUGE.FOR is able to convert the given gauge values inot corresponding discharge values using the stage discharge relationship Eq.4.2.

4.2.4. ESTIMATION OF EFFECTIVE RAINFALL AND DIRECT SURFACE RUNOFF:

(i) The method used here for baseflow separation is by assuming a constant baseflow. Program LOSS.FOR computes the average rainfall over the basis; and then the excess rainfall hyetograph after accounting for the hydrologic abstractions using index method so that the volumes of effective rainfall and DSRO are equal.

(ii) Computation of excess rainfall hyetograph after accounting for the hydrologic abstractions is done by using Corps of Engrs Procedure wherein separation of effective rainfall is done station-wise and the average effective rainfall is calculated by the Thiessen method (Program RFSEP.FOR). It also separates the base flow from the discharge hydrograph.

4.2.5. UNIT HYDROGRAPH DERIVATION:

1. EXACT METHOD

a. **Matrix Inverse Method:**

Let us define I_1 , I_2 ...., I_K to be the quantities of effective rainfall in intervals of D beginning at $t = 0$, i.e., I_i is the amount of effective rainfall in the time interval between (i-1) D and iD; h_1, h_2 .....h_n,

are the ordinates of the UH of duration D at intervals D starting with h_1 at time D of effective rainfall and Q_1, Q_2........Q_n are the ordinates of direct runoff hydrograph per unit watershed area at intervals at D beginning at t=0 i.e., Q_i is at t=iD. By definition,

$$Q_0 = 0$$

$$Q_1 = I_1 h_1$$

$$Q_2 = I_2 h_1 + I_1 h_2$$

$$Q_3 = I_3 h_1 + I_2 h_2 + I_1 h_3$$

$$Q_{K+n-1} = \sum_{i=1}^{K+n-1} h_i \, I_{K+n-i} \qquad \text{(Eq. 4.3)}$$

Afternatively, this can also be written as

$$\{Q\}_{n,1} = [I]_{n,n} \{h\}_{n,1}$$

$$\{h\} = \begin{Bmatrix} h_1 \\ h_2 \\ \vdots \\ h_n \end{Bmatrix} \quad \text{and} \left[I\right] = \begin{bmatrix} I_1 & 0 & 0 & 0 & 0 \\ I_2 & I_1 & 0 & 0 & 0 \\ \vdots & I_2 & I_1 & 0 & 0 \\ \vdots & \vdots & I_2 & I_1 & 0 \\ & \vdots & \vdots & I_2 & I_1 \end{bmatrix}$$

So,

$$\{h\}_{n,1} = [I]^{-1}_{nxn} \{Q\}_{nx1}$$

2. METHOD OF LEAST SQUARES

The method of least squares is based on minimising the sum of the squares of differences between observed hydrograph and computed hydrograph ordinates. Using matrix notation

$$\{Q\} = [I]\,\{h\}$$

$$\begin{Bmatrix} Q_1\\ Q_2\\ \vdots \\ \vdots \\ Q_p\end{Bmatrix}_{p\times1} = \begin{bmatrix} I_1 & 0 & 0 & 0 & 0\\ I_2 & I_1 & 0 & \vdots & 0 \\ \vdots & I_2 & I_1 & \vdots & \vdots\\ \vdots & \vdots & I_2 & I_{k-1} & \vdots\\ I_k & & \vdots & I_k & I_{k-1}\\ 0 & 0 & \vdots & 0 & I_k\end{bmatrix}_{p\times n} \begin{Bmatrix} h_1\\ h_2\\ \\ \\ h_n\end{Bmatrix}_{n\times1}$$

where generally, $n \leq p-k+1$

The inverse for the precipitation matrix (I^{-1}) exists and unique only if it is a square matrix with a non vanishing determinant.

By method of least squares, the unit hydrograph matrix is obtained as,

$$h = (I^T I)^{-1}\, I^T\, Q \qquad \text{(Eq.4.4)}$$

3. CONCEPTUAL MODELS

The representation of UH in terms of large number of ordinates is often cumbersome. Particularly when it is desired to consider the variation of UH in a basin as a function of rainfall characteristics; or among the basins, in terms of hydrogeomorphological parameters and physiographic characteristics of the basin. In such cases it is desirable to fit a functional form to the UH in terms of a few parameters. These can inturn be explained in terms of conceptual models, differential equations or time series.

A. DERIVATION OF UNIT HYDROGRAPH USING NASH MODEL

Nash considered that the Instantaneous Unit Hydrograph can be obtained by routing the inflow through a cascade of linear reservoirs with equal storage co-efficient. The outflow from the first reservoir is considered as inflow to the second reservoir and so on. The mathematical equation developed from general differential equation for the unit hydrograph is given as:

$$U(T,t) = (1/T)\ \{I(N,t/K) - I(N,\ ((t-T)/K))\} \quad \text{(Eq.4.5)}$$

where,

$U(T,t)$ = t^{th} ordinate for the unit hydrograph of duration T

$I(N,t/K)$ = incomplete gamma function of order N at (t/K)

$I(N,(t-T)/K)$ = incomplete gamma function of order N at $(t-T)/k$

N,K = the parameters of Nash Model

It can be seen from the above equation that the UH of duration T may be derived only when the values of two parameters, N and K are known. Several methods, namely method of moments, method of least squares and optimization methods are used for the purpose of the paramenter estimation. The unit hydrograph ordinates obtained from the above equation are convoluted with excess rainfall in order to get the computed direct surface runoff. The equation

which relates the excess rainfall, unit hydrograph and direct surface runoff is given as:

$$Q(i) = \sum_{i=1}^{n} \sum_{j=1}^{i} U(j) * \bar{X}(i-j+1) \quad \text{(Eq.4.6)}$$

where

$Q(i)$ = direct surface runoff at basin outlet at the end of computation interval i,

$U(j)$ = j^{th} ordinate of unit hydrograph

$X(i)$ = average rainfall excess for computational interval i, and

n = no of rainfall excess ordinates.

This is the same as the last line of Eq.4.3

ESTIMATION OF PARAMETERS:

The parameters, N and K, of the Nash model are estimated using the following procedure for two methods, viz., (i) method of moments, and (ii) method of least squares.

(i) Method of Moments:

Let r^{th} moment about the origin of direct surface runoff hydrograph be

$$
{}_{r}M'_{q} = \frac{\sum_{i=1}^{n} ((Q_i + Q_{i+1})/2)\,\Delta t (t_i - \Delta t/2)^r}{\sum_{i=1}^{n} ((Q_i + Q_{i+1})/2)\,\Delta t} = \frac{\sum_{i=1}^{n} Q_i (t_i - \Delta t/2)^r}{\sum_{i=1}^{n} Q_i}
$$

(Eq.4.7)

r equal to one and two in the above equation gives first and second moment about the origin of surface runoff hydrograph.

For the effective rainfall hyetograph,

$$
{}_{r}M'_{x} = \frac{\sum_{i=1}^{k} x_i \;\Delta t\, (t_i - \Delta t/2)}{\sum_{i=1}^{k} x_i \;\Delta t} = \frac{\sum_{i=1}^{k} x_i\, (t_i - \Delta t/2)}{\sum_{i=1}^{k} x_i \;\Delta t}
$$

(Eq. 4.8)

where

Q_i = Uniform rate of runoff for the i^{th} interval,

n = Number of runoff intervals,

x_i = Effective rainfall for the i^{th} interval,

k = Number of rainfall blocks,

r = r^{th} moment about the origin

$t_i - \Delta t/2$ = time to the midpoint of the i^{th} interval from the origin,

Δt = time interval

Nash (1959), related moments of input and output with moments of impulse response as follows:

$$_1M'_q - {}_1M'_x = {}_1M'_u = NK \qquad \text{(Eq.4.9)}$$

$$_2M'_q - {}_2M'_x = N(N+1)K^2 + 2NK\ {}_1M'_x \qquad \text{(Eq.4.10)}$$

where,

$_1M'_q$ and $_2M'_q$ = first and second moment about the origin of the direct surface runoff hydrograph respectively,

$_1M'_x$ and $_2M'_x$ = first and second moment about the origin of the effective rainfall hyetograph respectively.

$_1M'_u$ and $_2M'_u$ = first and second moment about the origin of UH ordinates respetively.

It is known that for the Nash Model,

$$_1M'_u = NK$$

$$_2M'_u = N(N+1)K^2$$

Substituting the values of moments in Eqs.4.9 and 4.10 and solving these equations, the values of parameters N and K are obtained. The computer program NASHM.FOR uses this procedure to estimate the parameters N and K.

(ii) **METHOD OF LEAST SQUARES (OPTIMISATION TECHNIQUE):**

In this method the paramenters are estimated by a suitable error criterion, say, minimising the sum of the squares of differences between observed and computed hydrographs using data of all storms used in calibration.

There exists a plethora of optimisation methods (Rosen brock, 1960; Palmer, 1969; Decoursey and Snyder, 1969; Sorooshian and Gupta, 1983) which can be used to estimate model parameters. All optimisation methods require specification of an objective function or error criterion. The program requires some initial estimate of parameters, N and K, and estimates the parameters by searching in the direction of steepest gradient of the objective function for its minimum value.

The computer program CONTI.FOR developed by NIH, Roorkee, uses a Quasi-Newton procedure to estimate the parameters and corresponding unit hydrograph ordinates for least squares error criterion.

4. INVERSE SYSTEM MODELLING:

In an inverse model developed by Chaube et al, a three parameter Nash model consisting of a linear Channel with a delay time and a nash model for storage routing is assumed.

$$\{Q\} = [U]\{I\}$$

$$\{I\} = [U]^{-1}\{Q\} \qquad \text{(Eq.4.11)}$$

Estimation of I by this method is known as detection.

The detected effective rainfall should satisfy the continuity equation with respect to the storm precipitation from which it is derived and the DSRO which is in turn

derived from it. A computer program developed by Mr. A.K. Sharma for such inverse system modelling is available for the study.

4.3 STRUCTURE OF MENU BASED PROGRAM:

The structure of the program is as follows:

(i) Input Data is given to the program. Input may be in any one of the following forms:

  (a) Effective rainfall and Direct Surface runoff values.

  (b) Total rainfall and discharge values.

  (c) Stage, rating curve and rainfall values.

(ii) Depending upon the input type, preliminary analysis is done. If total rainfall and discharge values are given as input, effective rainfall and direct surface runoff values can be calculated.

If the stage values are given and rainfall is given, then the given stage values are converted into corresponding discharge values using a given rating curve in the form: $Q = a(G-e)^b$. Now, total discharge and rainfall values are available. Effective rainfall and DSRO may now be calcualted. Input data are used to derive unit hydrographs using different methods.

4.3.1 INTERACTIVE PROGRAM

A non interactive computer programs written in Fortran Language for unit hydrograph were available for the study. The programs were modified in terms of subroutines.

The different programs used are as follows:

1. RFSEP.FOR This program separates the base flow discharge hydrograph and computes the excess rainfall hyetograph using corps of Engineers procedure.

2. LOSS.FOR This computer program separates the base flow discharge hydrograph using straight line technique and also computes the excess rainfall hyetogrph after accounting for the hydrologic abstractions using index method.

3. RATING.FOR This program is used for developing the rating curve in the form of $Q = a(G-e)^b$.

4. GAUGE.FOR This program is used for converting the given stage values into corresponding discharge values using a given rating curve in the form $Q = a(G-e)^b$.

5. CONTI.FOR This program separates the base flow and estimates sum of squares of the differences between the observed and computed discharge hydrograph ordinates. The program also computes the unit hydrograph and the values of the error functions.

6. NASHM.FOR The program computes the unit hydrograph by method of moments and estimates sum of squares of the differences between the observed and computed discharge hydrograph ordinates.

The above programs are developed by NIH, Rōorkee. They are modified and used here.

7. EX.FOR This program assumes the data to be without error and so calculates the unit hydrograph ordinates using the Matrix Inversion Method.

8. MLS.FOR This program calculates the unit hydrograph ordintes using method of lease squres.

9. INV.FOR This program developed by Mr. A.K. Sharma (1973) calculates unit hydrograph ordinates, total effective rainfall, total precipitation, total storage and total abstraction, on the basis of detected effective rainfall.

4.4. DEVELOPMENT OF MENU BASED PROGRAM

A program is written to develop a pop-up menu for Unit Hydrograph Analysis. The program is developed in the following way:

(i) All the mouse parameters have been defined using BEGIN statement as given in Appendix A.

(ii) A main menu has been prepared in which various options for sub-menus are given. Main menu has been developed using the 'MENU' command. The

syntax is given in Appendix A.

(iii) Options of main menu are sub-menus or commands. Sub menus are as follows:

a. DATA INPUT

Input type has been given in this option. Three different options are given in this sub menu.

b. FILES

Two options are given here. First, to retrieve the files and second to print the files. A pop-up menu has been developed to retrieve the input, output and program files .

c. PERLIMINARY ANALYSIS

This sub menu gives options for effective rainfall and DSRO separation; and only DSRO separation.

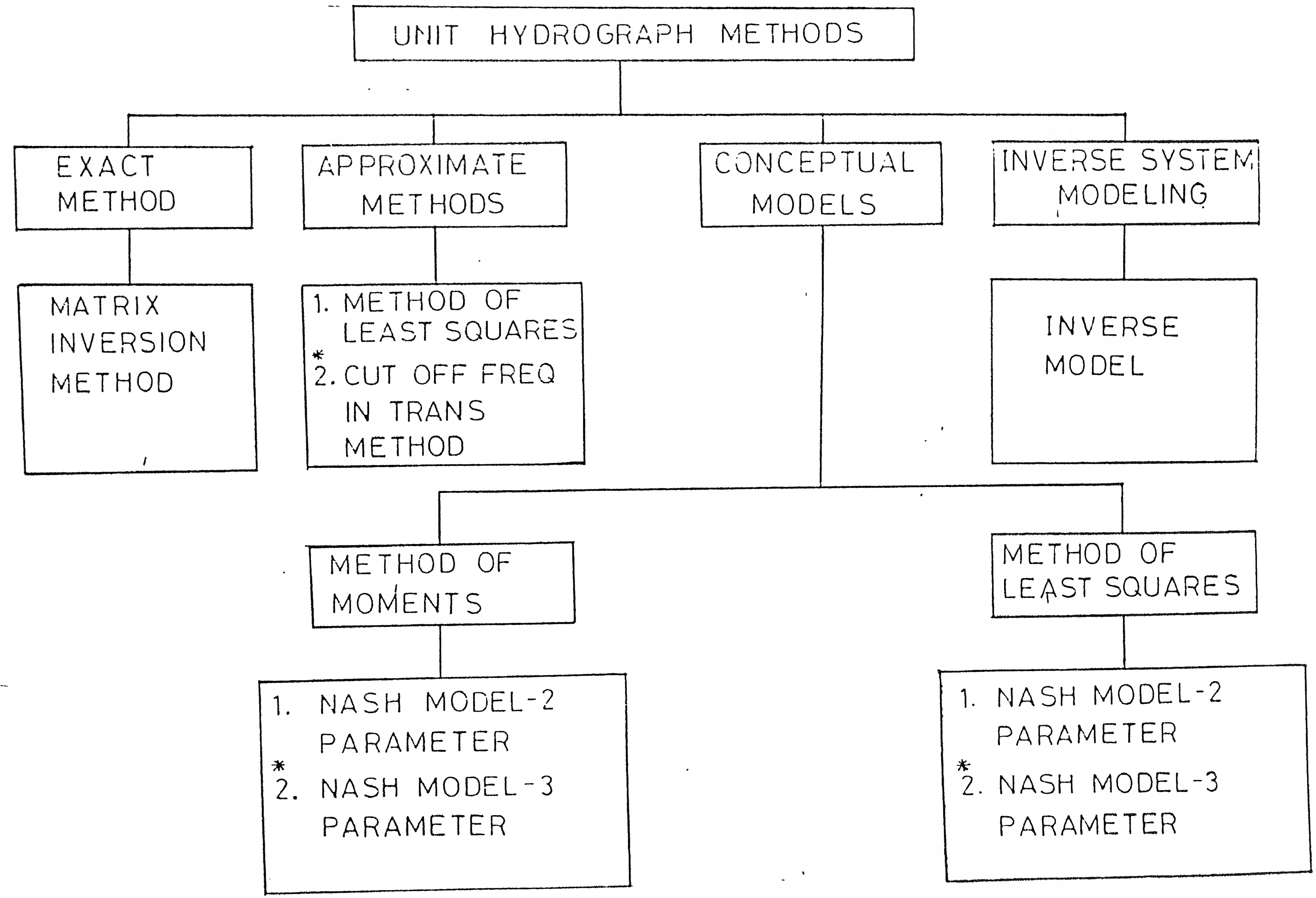
d. UNIT HYDROGRAPH METHODS

This submenu gives different unit hydrograph methods available for analysis. Each option gives different methods coming under it.

Different unit hydrograph methods (Sec.4.2.5) and their sub menus are given in Table 4.1

Listing of menu making program is given in Appendix B.

TABLE 4.1



* Not implemented

4.5.3 ANALYSIS AND DISCUSSION OF RESULT:

Four different methods have been used for analysis to demonstrate interactive menu based UH analysis. They are Exact_method, Method of Least Squares, Conceptual models and Inverse model. Under conceptual model, 2-parameter Nash model by method of moments and 2-parameter Nash model by method of least squares (optimisation technique) have been implemeted.

To perform the analysis by Exact method, i.e., by Matrix Inversion method, input file named PROG.DAT has been opened with the data in the form as given in Sec. 4.5.2. Input data are given in Table 4.2. Effective rainfall and DSRO separation are done using Corps of Engrs. procedure. Effective rainfall and DSRO values are then used to derive the unit hydrograph.

Result from this method is given in Table 4.3. Unit hydrograph is shown in Fig. 4.1. From Fig. 4.1, hydrograph is steady upto t = 12 hours, but afterwards its oscillations are too large. The method used is inherantly unstable because of errors of data; so the graph is oscillating. So exact methods are not preferred in deriving unit hydrographs.

Second method used is the Method of Least Squares. This method uses the same input as given to Exact method with p = n-k+1. Results are shown in Table 4.3, and unit

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TABLE 4.2

INPUT DATAFOR MATRIX INVERSION METHOD AND
METHOD OF LEAST SQUARES

```
BASIN A
823.62
1.
1.
1
1Ø5.
1
1.
7
.544 1.1991 11.34 13.287 4.486 6.428 2.777
2Ø
55. 55. 6Ø. 65. 142. 285. 355. 37Ø. 43Ø. 44Ø.
285. 26Ø. 21Ø. 17Ø. 15Ø. 132. 12Ø. 115. 1Ø5. 1ØØ.
```

INPUT DATA FOR CONCEPTUAL MODELS AND
INVERSE MODEL

```
BASIN B
1ØØ.Ø
1.
1.
1
39.2Ø
3
Ø.51 Ø.39 Ø.19
14
14.8  3.6  3.Ø  Ø.Ø  Ø.Ø  9.2 1Ø.4 2Ø.Ø 1Ø.6 1Ø.8
7.Ø  8.8  5.4  2.Ø
Ø.Ø 25.Ø 18.Ø 11.2  9.8 22.6 1Ø.2  8.4  2.6  1.Ø
11.Ø  7.6  2.4  Ø.Ø
14.6  1.4  Ø.Ø  Ø.Ø 1Ø.Ø  3.6 23.Ø 28.6 1Ø.Ø 13.Ø
4.2  3.Ø  2.Ø  Ø.8
26
39.2Ø  39.2Ø  44.64  5Ø.66  57.31  64.64  72.7Ø  81.53
81.54  91.2Ø 1Ø1.76 113.28 125.8Ø 139.41 139.41 125.8Ø
113.28 113.28  91.2Ø  81.54  72.7Ø  64.64  57.31  5Ø.66
44.64  39.2Ø
```

TABLE 4.3

RESULT FROM MATRIX INVERSION METHOD

NUMBER OF UNIT HYDROGRAPH ORDINATE = 20

	UNIT HYDROGRAPH ORDINATE
1	.00
2	.00
3	.00
4	.00
5	10.95
6	35.99
7	17.21
8	51.27
9	15.31
10	74.97
11	-64.97
12	148.31
13	-202.81
14	339.04
15	-521.33
16	830.09
17	-1304.55
18	2060.14
19	-3248.68
20	5122.91

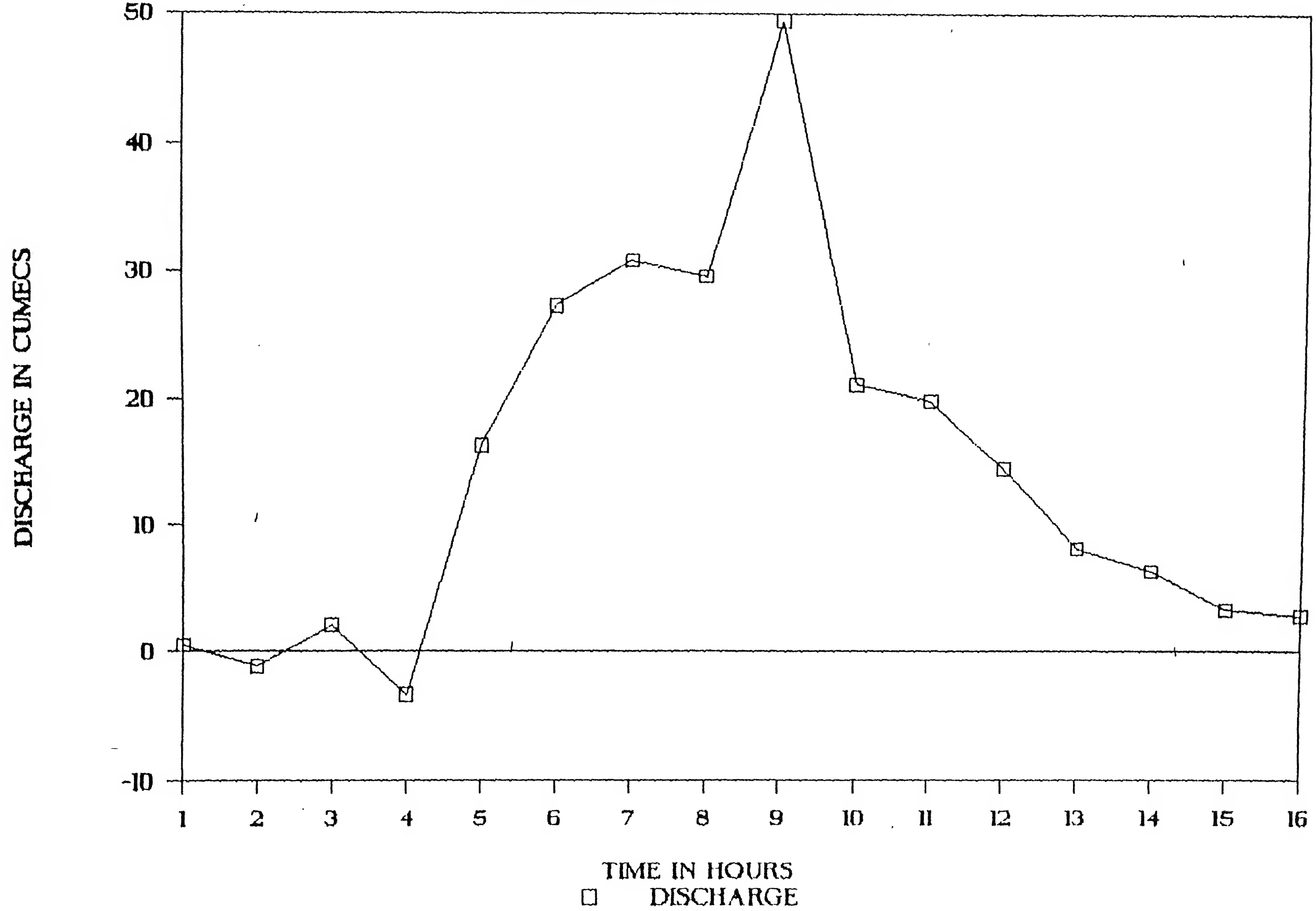
RESULT FROM METHOD OF LEAST SQUARES

NUMBER OF UNIT HYDROGRAPH ORDINATES = 16

	UNIT HYDROGRAPH ORDINATE
1	.53
2	-1.18
3	2.07
4	-3.41
5	16.41
6	27.33
7	30.90
8	29.65
9	49.42
10	21.18
11	19.87
12	14.53
13	8.16
14	6.36
15	3.28
16	2.81

FIG.4.2 UNIT HYDROGRAPH

METHOD OF LEAST SQUARES



hydrograph is shown in Fig. 4.2. The hydrograph derived is an improvement over the previous one. This method gives better unit hydrgograph because it minimises the sum of the squares of differences between observed hydrograph and computed hydrograph ordinates.

The third one is a conceptual model. Different Input data are used here. Input file named NASHPRO. DAT has been opened with the data in the form as given in Sec. 4.5.2. Table 4.2 gives input data. 2-parameter Nash model using optimisation technique for Method of Least Squares is the first model used in the study under conceptual model. Observed hydrograph, simulated hydrograph, base flow and direct surface runoff are shown in Fig. 4.3. The simulated hydrograph is approximately same as the observed hydrograph. So this model is satisfactory for hydrograph analysis. The corresponding unit hydrograph is shown in Fig. 4.4. Results of this model are given in Table 4.4.

2-parameter Nash model using method of moments is the other model used in the study. The observed hydrograph, simulated hydrograph, base flow and Direct surface runoff are shown in Fig 4.5. Simulated hydrograph values are somewhat different from the observed hydrograph. So if simulated hydrograph is shifted by 3 hours then simulated and observed hydrograph are nearly same. So 3-parameter Nash model taking the 3 hour lag time as the third parameter, gives good result. 3 hour shifted simulated hydrograph,

FIG. 4.3 HYDROGRAPH

2-PARAMETER NASH MODEL (MLS)

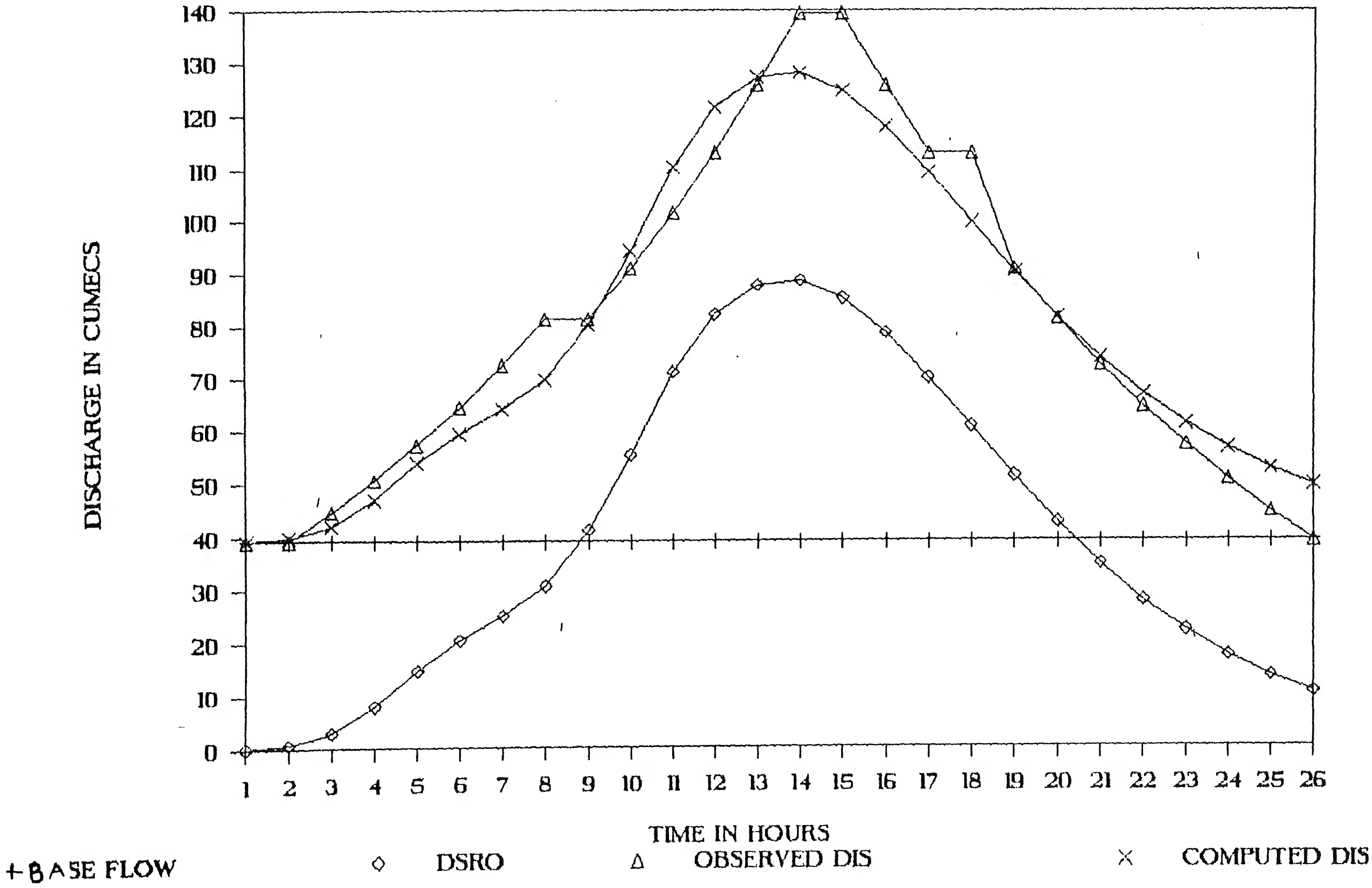


FIG.4.4 UNIT HYDROGRAPH

2-PARAMETER NASH MODEL (MLS)

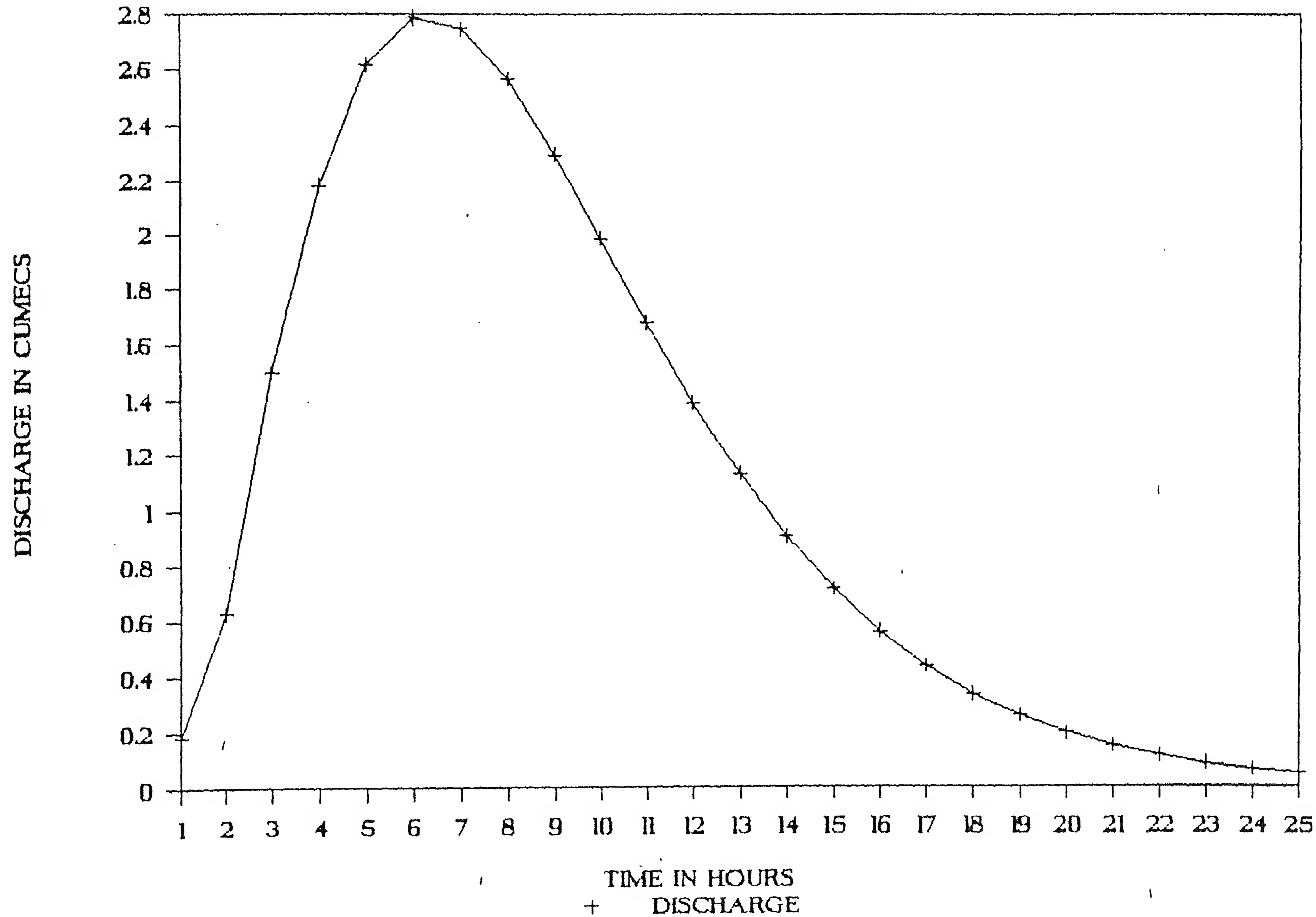


TABLE 4.4 UNIT HYDROGRAPH ANALYSIS -NASH MODEL
(METHOD OF LEAST SQUARES)

```
  EXCESS RAIN AND DIR.SURFACE RUNOFF DETAILS FOR              EVENT NO =    1
 NAME OF THE CATCHMENT      BASIN B
 CATCHMENT AREA =            100.00
                              DIRECT SURFACE RUNOFF (CUMECS)

     .000     .000    5.440  11.460  18.110  25.440  33.500  42.330  42.340  52.000
   62.560   74.080   86.600 100.210 100.210  86.600  74.080  74.080  52.000  42.340
   33.500   25.440   18.110  11.460   5.440    .000
                  BASEFLOW (CUMECS)
   39.200   39.200   39.200  39.200  39.200  39.200  39.200  39.200  39.200  39.200
   39.200   39.200   39.200  39.200  39.200  39.200  39.200  39.200  39.200  39.200
   39.200   39.200   39.200  39.200  39.200  39.200
  INFILTRATION CAPACITY (MM/HR)          7.206
  TOTAL      RAINFALL EXCESS (MM)       38.784

                              SEPERATED  RAINFALL VALUES (MM)
    3.116    4.646    1.344    .000    .000   6.984   6.446  11.704   1.114   1.162
    1.452     .816     .000    .000
  NO. OF U.H. ORDINATES =   25

OPTQN CALLED WITH ARGUMENTS
NO. OF PARAMETERS:      2
TOLERANCE :            .10000
INITIAL PARAMETERS

     1      3.00000
     2      2.00000


ITERATION NO.   :     2
     1       20.694730        20.694730
     2       29.563900        29.563900


LINE SEARCH COMPLETED
LINE ITERATION NO:      7
 OLD FUNCTION VALUE :      .115443E+02
 NEW FUNCTION VALUE :      .867813E+01
  CURRENT SOLUTION

     1     3.646710
     2     2.923872
  STPMAX,GMAX              .923872E+00          .151668E+02
  PRE UPDATED HESSIAN
  MULTIPLIERS             -.000768          .015701
  VECTORS
      1    20.694730   34.581250
      2    29.563900   44.730730
      1     .100000E+01
      2     .000000E+00
      3     .100000E+01
  UPDATED HESSIAN
      1     .999747E+00
      2    -.360837E-03
      3     .999485E+00
```

LINE SEARCH COMPLETED
LINE ITERATION NO: 201
OLD FUNCTION VALUE : .161796E+01
NEW FUNCTION VALUE : .161796E+01
CURRENT SOLUTION

1 3.301194
2 2.506824
STPMAX,GMAX .119209E-06 .105332E+01

AREA OF UH= .99564

UNIT HYDROGRAPH ORDINATES(CUMECS)

.183	.631	1.500	2.183	2.615	2.787	2.750	2.567	2.299	1.994
1.686	1.395	1.135	.909	.719	.563	.436	.335	.256	.194
.146	.109	.081	.060	.045					

U.H.PEAK(M**3/S)= 3.
U.H.TIME TO PEAK(HRS)= 6
EVENT NO. = 1

ESTIMATED DIRECT SURFACE RUNOFF	BASEFLOW
.573	39.200
2.825	39.200
7.870	39.200
14.656	39.200
20.358	39.200
25.111	39.200
30.697	39.200
41.312	39.200
55.429	39.200
71.329	39.200
82.357	39.200
88.093	39.200
88.923	39.200
85.520	39.200
78.862	39.200
70.267	39.200
60.855	39.200
51.469	39.200
42.670	39.200
34.781	39.200
27.941	39.200
22.164	39.200
17.390	39.200
13.512	39.200
10.410	39.200

TABLE 4.4(Contd.)

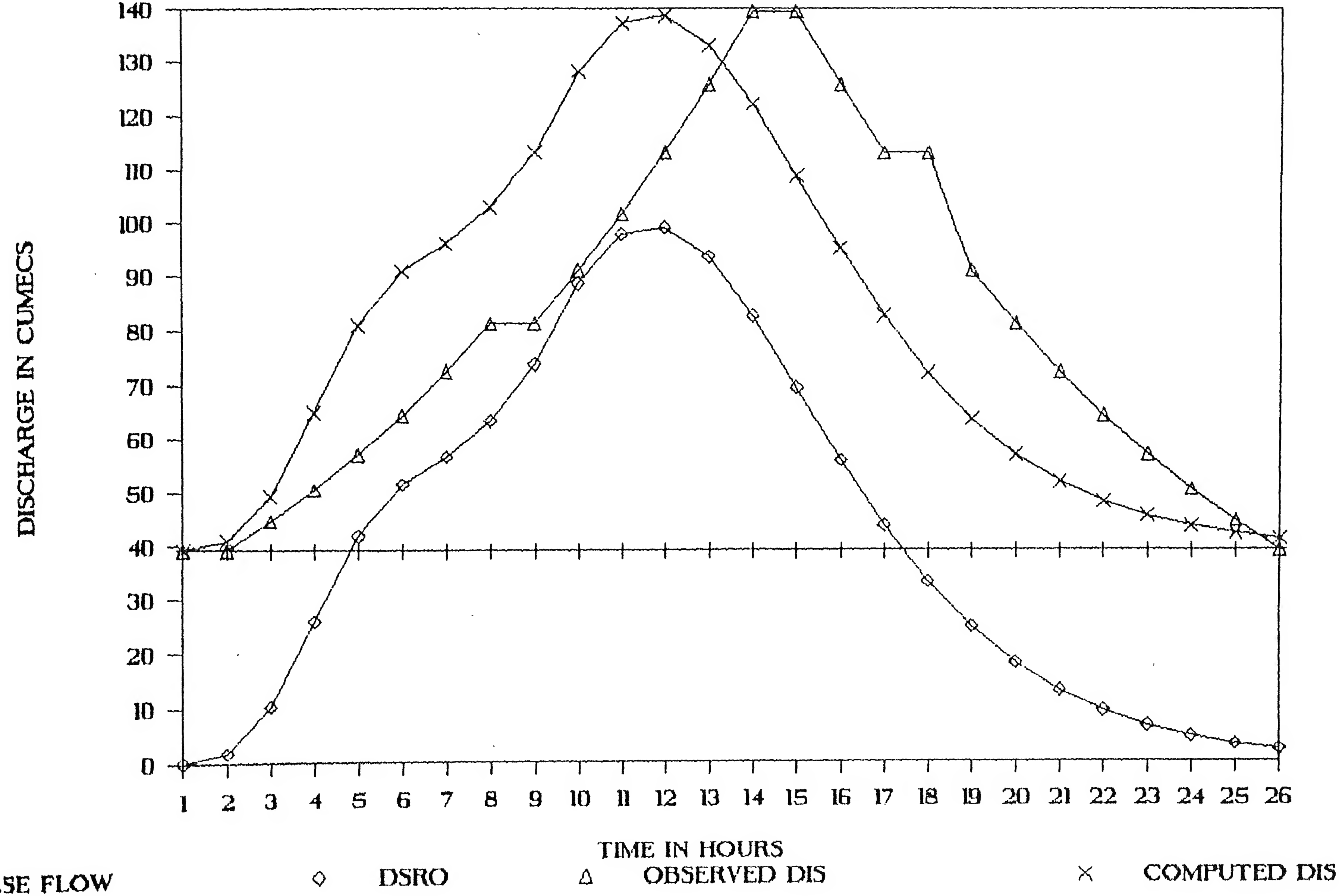
COMPARISON OF OBSERVED AND SIMULATED HYDROGRAPH

NO.	OBSD DISCHARGE	COMPD DISCHARGE
1	39.20	39.20
2	39.20	39.77
3	44.64	42.02
4	50.66	47.07
5	57.31	53.86
6	64.64	59.56
7	72.70	64.31
8	81.53	69.90
9	81.54	80.51
10	91.20	94.63
11	101.76	110.53
12	113.28	121.56
13	125.80	127.29
14	139.41	128.12
15	139.41	124.72
16	125.80	118.06
17	113.28	109.47
18	113.28	100.06
19	91.20	90.67
20	81.54	81.87
21	72.70	73.98
22	64.64	67.14
23	57.31	61.36
24	50.66	56.59
25	44.64	52.71
26	39.20	49.61

EFFICIENCY OF THE MODEL= 95.22
OBSERVED PEAK(M**3/S)= 139.41
OBSERVED TIME TO PEAK(HRS)= 14
COMPUTED PEAK (M**3/S)= 128.12
COMPUTED TIME TO PEAK (HRS)= 14
AVERAGE STANDARD ERROR = 6.934
AVERAGE ABSOLUTE ERROR = 5.469
AVERAGE PERCENTAGE ABSOLUTE ERROR = 7.158
PERCENTAGE ABSOLUTE ERROR IN PEAK= 8.10
PERCENTAGE ABSOLUTE ERROR IN TIME TO PEAK= .00

FIG. 4.5 HYDROGRAPH

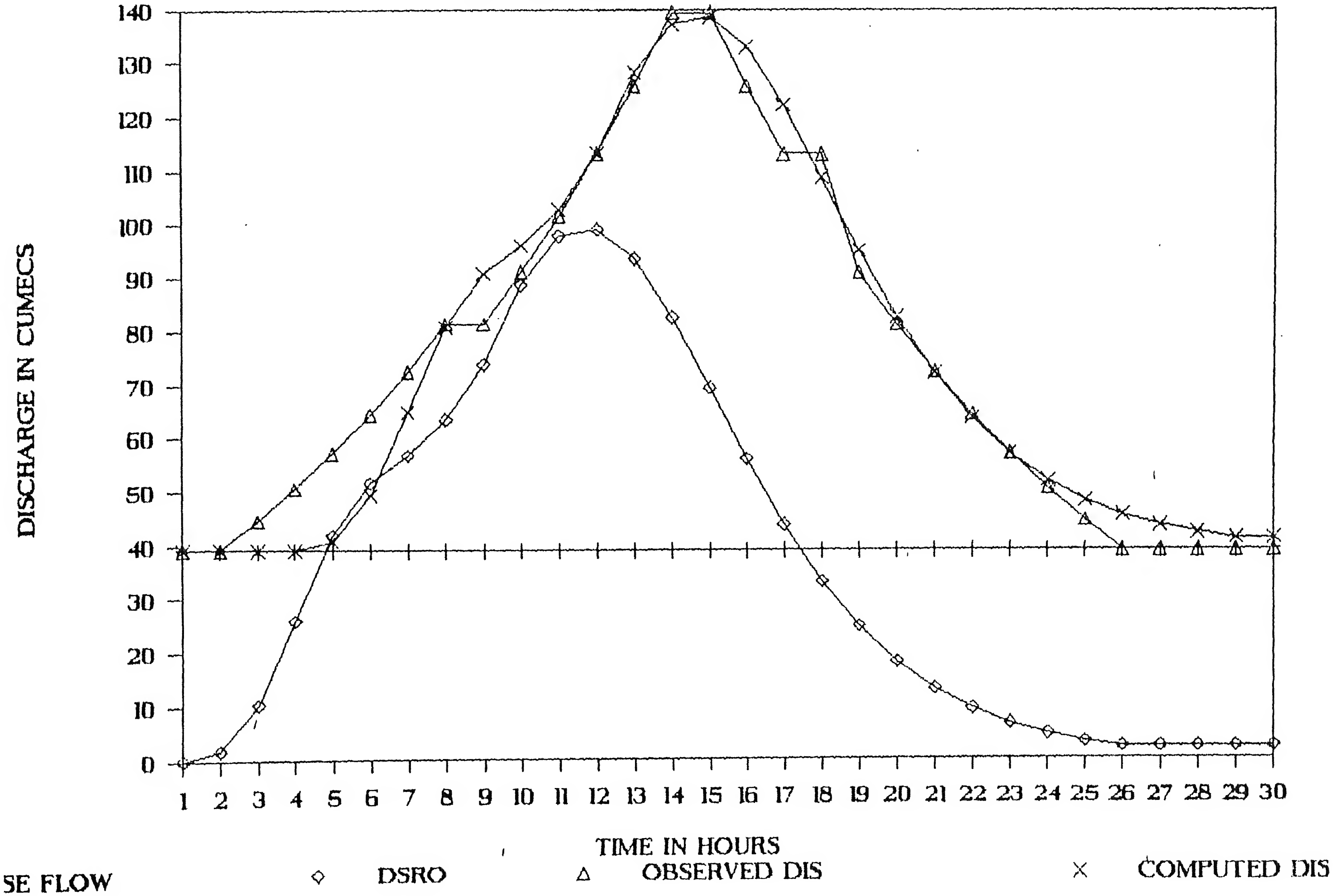
2-PARAMETER NASH MODEL (MOM)



+ BASE FLOW

FIG. 4.6 HYDROGRAPH 3-HR SHIFTED

2-PARAMETER NASH MODEL(MOM)



observed hydrograph, base flow and direct surface runoff are shown in Fig 4.6. The corresponding unit hydrograph is shown in Fig. 4.7. Results of this model are given in Table 4.5.

The conceptual model (3-parameter Nash model) seems to give the best results.

Fourth model used in the study is Inverse model. Input data for the model is same as for conceptual models. Total precipitation and direct surface runoff values are used in this model. Cumulative effective precipitation, cumulative precipitation, cumulative abstraction and total storage have been calculated for the linear reservoir. Fig. 4.8 shows all these values. It may be noted that the cumulative precipition is always in excess of the cumulative DSRO, which in turn exceeds the cumulative DSRO. Thus maintaining the principle of conservation of mass.

The corresponding unit hydrograph is given in Fig. 4.9. The results are shown in table 4.6 and a single linear reservoir with exponential decay function as the UH is found to be generally satisfactory for the data analysed.

Fig. 4.10 shows rainfall separation by corps of Engrs. procedure, rainfall separation by inverse model and total precipitation. In corps of Engrs. procedure abstractions occur only during the storm, but in the inverse model abstractions occur after the end of the storm also. It may be noted that abstractions occur

TABLE 4.5 UNIT HYDROGRAPH ANALYSIS-NASH MODEL
(METHOD OF MOMENTS)

NAME OF THE CATCHMENT BASIN B
CATCHMENT AREA(SQ.KM) 1ØØ.ØØØ
NO OF RAINGAUGE STNS= 3

THEISSON WT. OF EACH RAINGAUGE STATION
.51ØØ .39ØØ .19ØØ

AVERAGE N 3.ØØØ
AVERAGE K (HRS) 2.ØØØ

TOTAL RAINFALL (MM)= 126.176
INFILTRATION CAPACITY (MM/HR) 8.77Ø
TOTAL RAINFALL EXCESS (MM) 38.784
RUNOFF COEFF= .3Ø74

I.U.H. ORDS(CUMECS)

1.Ø5Ø	2.548	3.477	3.749	3.553	3.1Ø3	2.562	2.Ø29	1.558	1.167
.856	.618	.44Ø	.3Ø9	.215	.149	.1Ø2	.Ø69	.Ø47	.Ø31
.Ø21	.Ø14	.ØØ9	.ØØ6	.ØØ4	.ØØ3				

SUM OF IUH= .99957
I.U.H. PEAK= 3.7488
I.U.H. TIME TO PEAK = 4

AREA OF UH= .99978

UNIT HYDROGRAPH ORDINATES(CUMECS)

.399	1.826	3.Ø71	3.661	3.68Ø	3.341	2.835	2.292	1.787	1.355
1.ØØ5	.731	.524	.371	.26Ø	.18Ø	.124	.Ø85	.Ø57	.Ø39
.Ø26	.Ø17	.Ø11	.ØØ8	.ØØ5	.ØØ3				

TABLE 4.5(Contd.)

COMPARISON OF OBSERVED AND COMPUTED HYDROGRAPHS USING NASH MODELS,AVERAGE PARAMETERS

ORD.NO.	RFSTN1	RFSTN2	RFSTN3	WTRFALL	EFF RFALL	BASE FLOW	D.S.R.O.	OBSD.DISCHARG	COMPD. DISCHARGE
1	14.80	.00	14.60	10.32	4.18	39.20	.00	39.20	39.20
2	3.60	25.00	1.40	11.85	6.33	39.20	1.67	39.20	40.87
3	3.00	18.00	.00	8.55	3.60	39.20	10.19	44.64	49.39
4	.00	11.20	.00	4.37	.95	39.20	25.91	50.66	65.11
5	.00	9.80	10.00	5.72	.64	39.20	41.82	57.31	81.02
6	9.20	22.60	3.60	14.19	5.61	39.20	51.75	64.64	90.95
7	10.40	10.20	23.00	13.65	4.09	39.20	56.92	72.70	96.12
8	20.00	8.40	28.60	18.91	9.49	39.20	63.73	81.53	102.93
9	10.60	2.60	10.00	8.32	1.17	39.20	74.07	81.54	113.27
10	10.80	1.00	13.00	8.37	1.34	39.20	88.86	91.20	128.06
11	7.00	11.00	4.20	8.66	.87	39.20	97.98	101.76	137.18
12	8.80	7.60	3.00	8.02	.02	39.20	99.33	113.28	138.53
13	5.40	2.40	2.00	4.07	.00	39.20	93.76	125.80	132.96
14	2.00	.00	.80	1.17	.00	39.20	83.01	139.41	122.21
15	.00	.00	.00	.00	.00	39.20	69.74	139.41	108.94
16	.00	.00	.00	.00	.00	39.20	56.21	125.80	95.41
17	.00	.00	.00	.00	.00	39.20	43.83	113.28	83.03
18	.00	.00	.00	.00	.00	39.20	33.27	113.28	72.47
19	.00	.00	.00	.00	.00	39.20	24.72	91.20	63.92
20	.00	.00	.00	.00	.00	39.20	18.04	81.54	57.24
21	.00	.00	.00	.00	.00	39.20	12.96	72.70	52.16
22	.00	.00	.00	.00	.00	39.20	9.19	64.64	48.39
23	.00	.00	.00	.00	.00	39.20	6.45	57.31	45.65
24	.00	.00	.00	.00	.00	39.20	4.48	50.66	43.68
25	.00	.00	.00	.00	.00	39.20	3.09	44.64	42.29
26	.00	.00	.00	.00	.00	39.20	2.11	39.20	41.31

U.H.PEAK(M**3/S)= 4.
U.H.TIME TO PEAK(HRS)= 5
EFFICIENCY OF THE MODEL= 47.37
OBSERVED PEAK(M**3/S)= 139.41
OBSERVED TIME TO PEAK(HRS)= 14
COMPUTED PEAK (M**3/S)= 138.53
COMPUTED TIME TO PEAK (HRS)= 12
AVERAGE STANDARD ERROR = 22.995
AVERAGE ABSOLUTE ERROR = 19.720
AVERAGE PERCENTAGE ABSOLUTE ERROR = 23.271
PERCENTAGE ABSOLUTE ERROR IN PEAK= .63
PERCENTAGE ABSOLUTE ERROR IN TIME TO PEAK= 14.29

FIG.4.7 UNIT HYDROGRAPH

2-PARAMETER NASH MODEL (MOM)

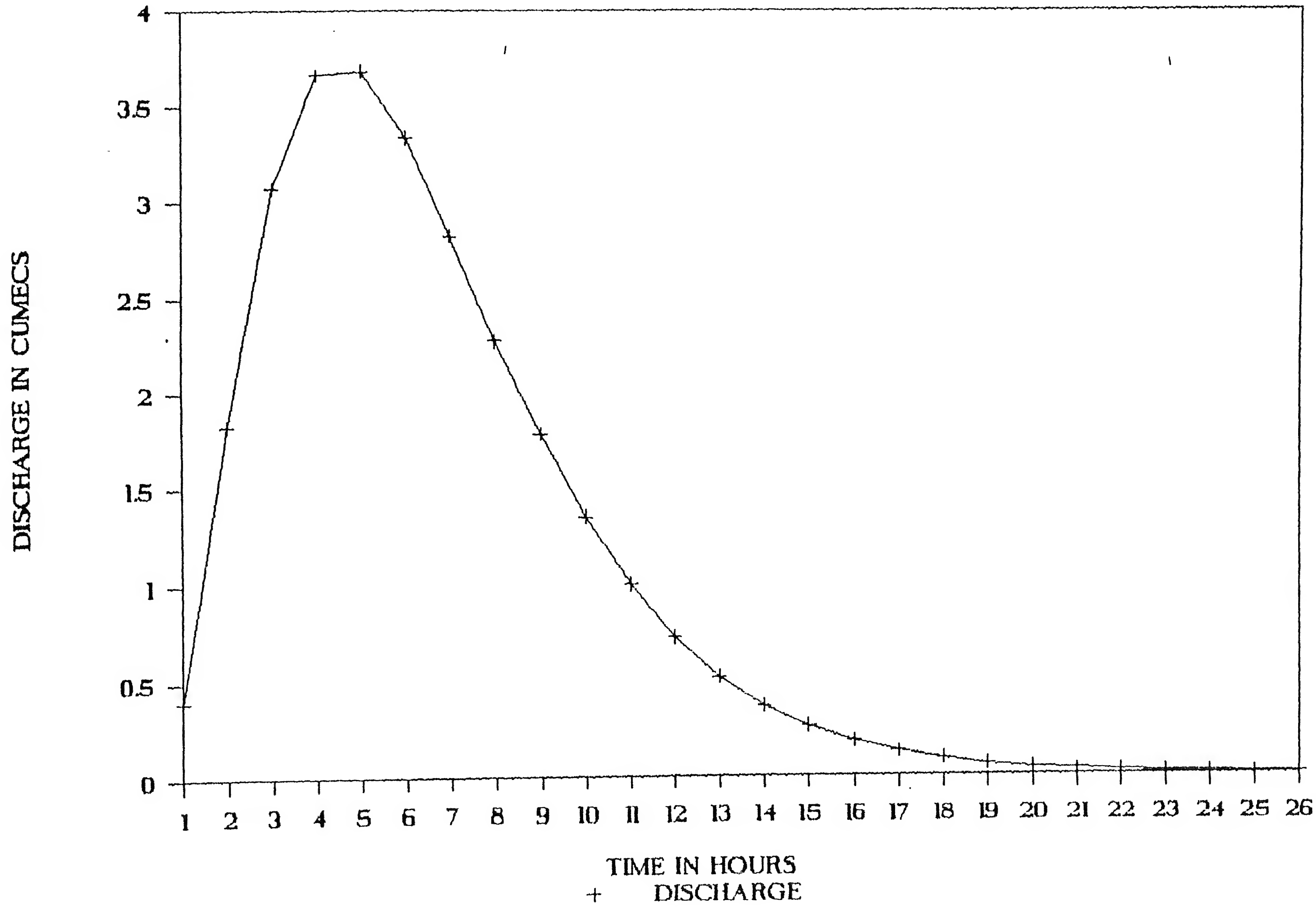
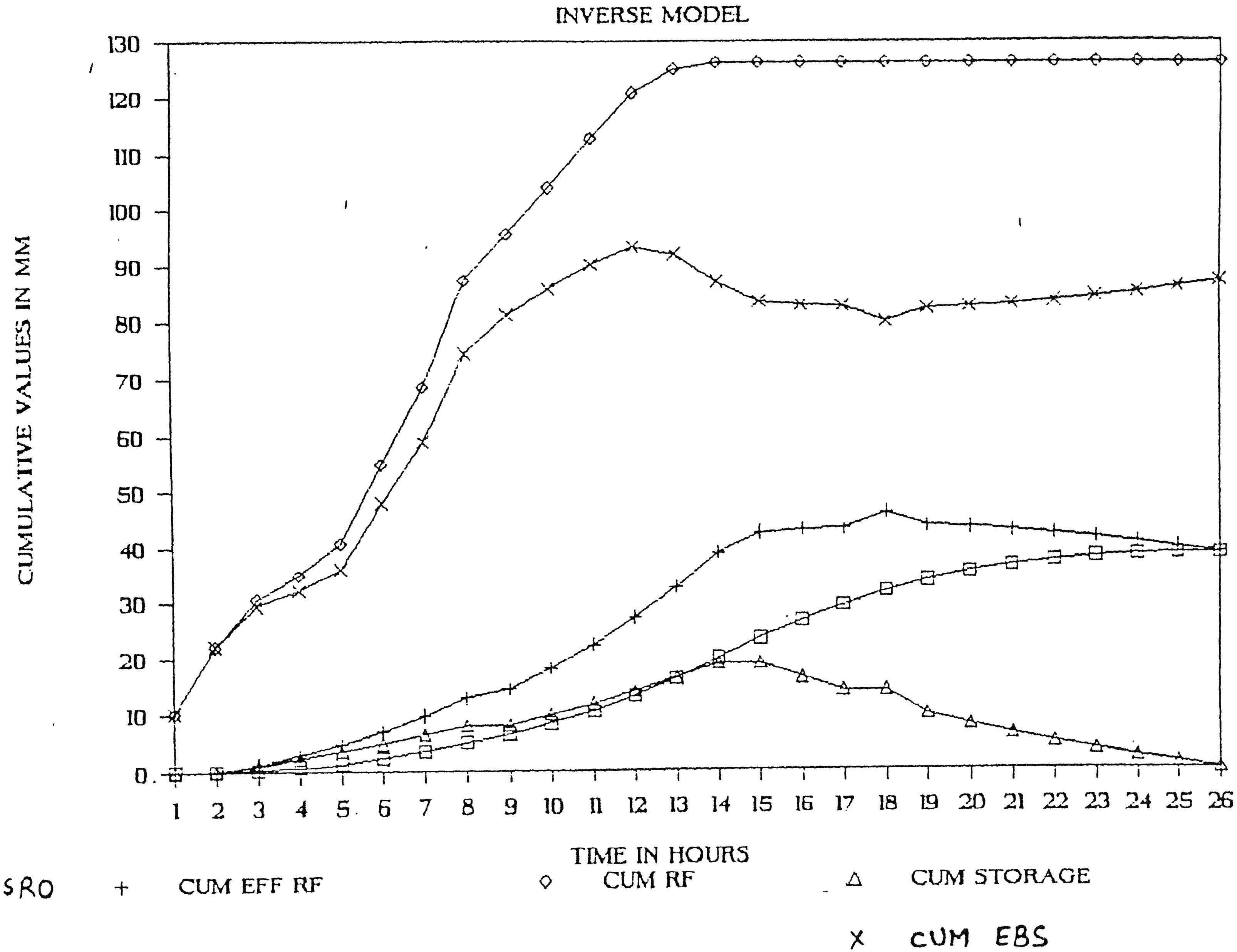


FIG.4.8 CUMULATIVE VALUES



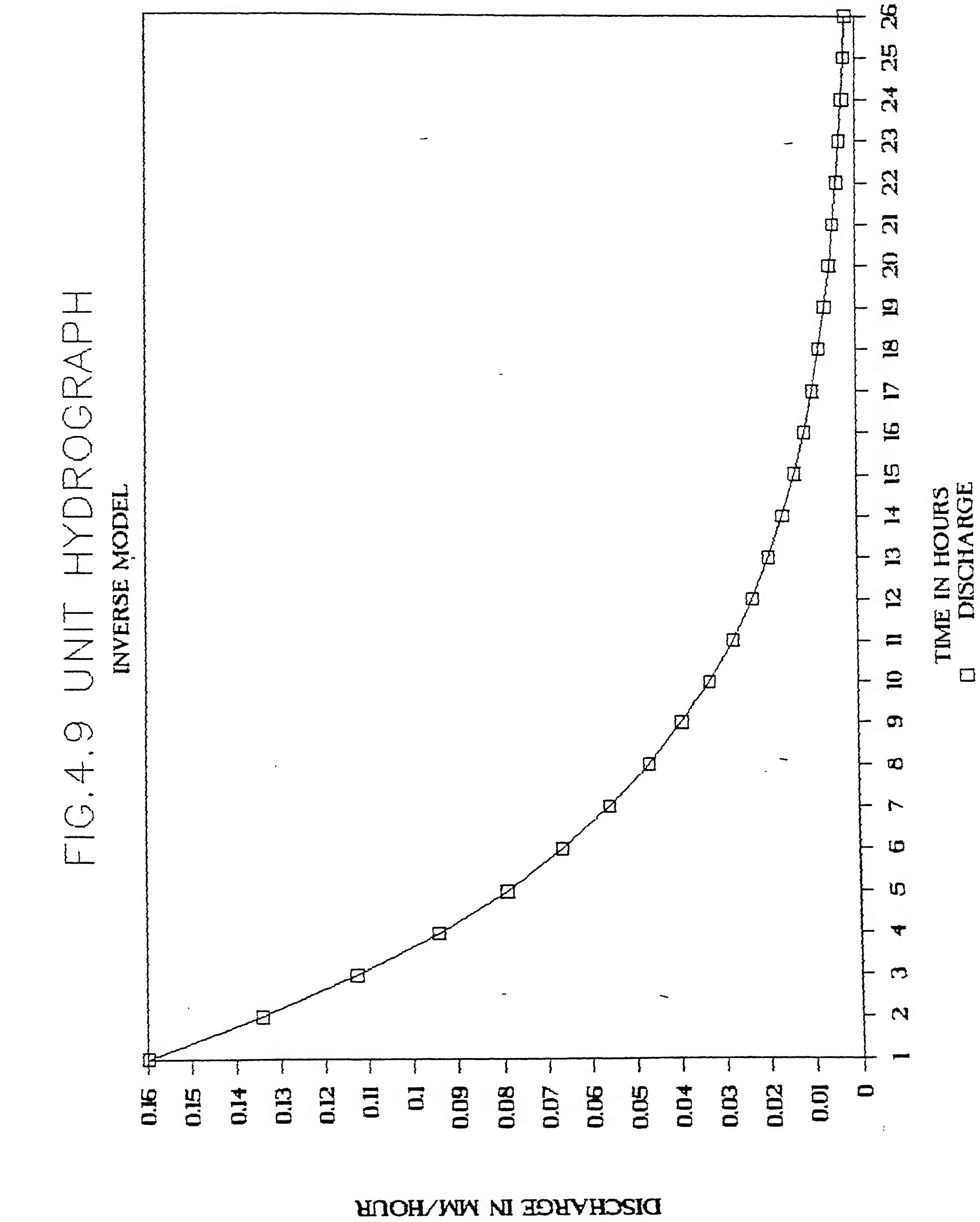


FIG.4.9 UNIT HYDROGRAPH

FIG.4.10 SEPARATED RF

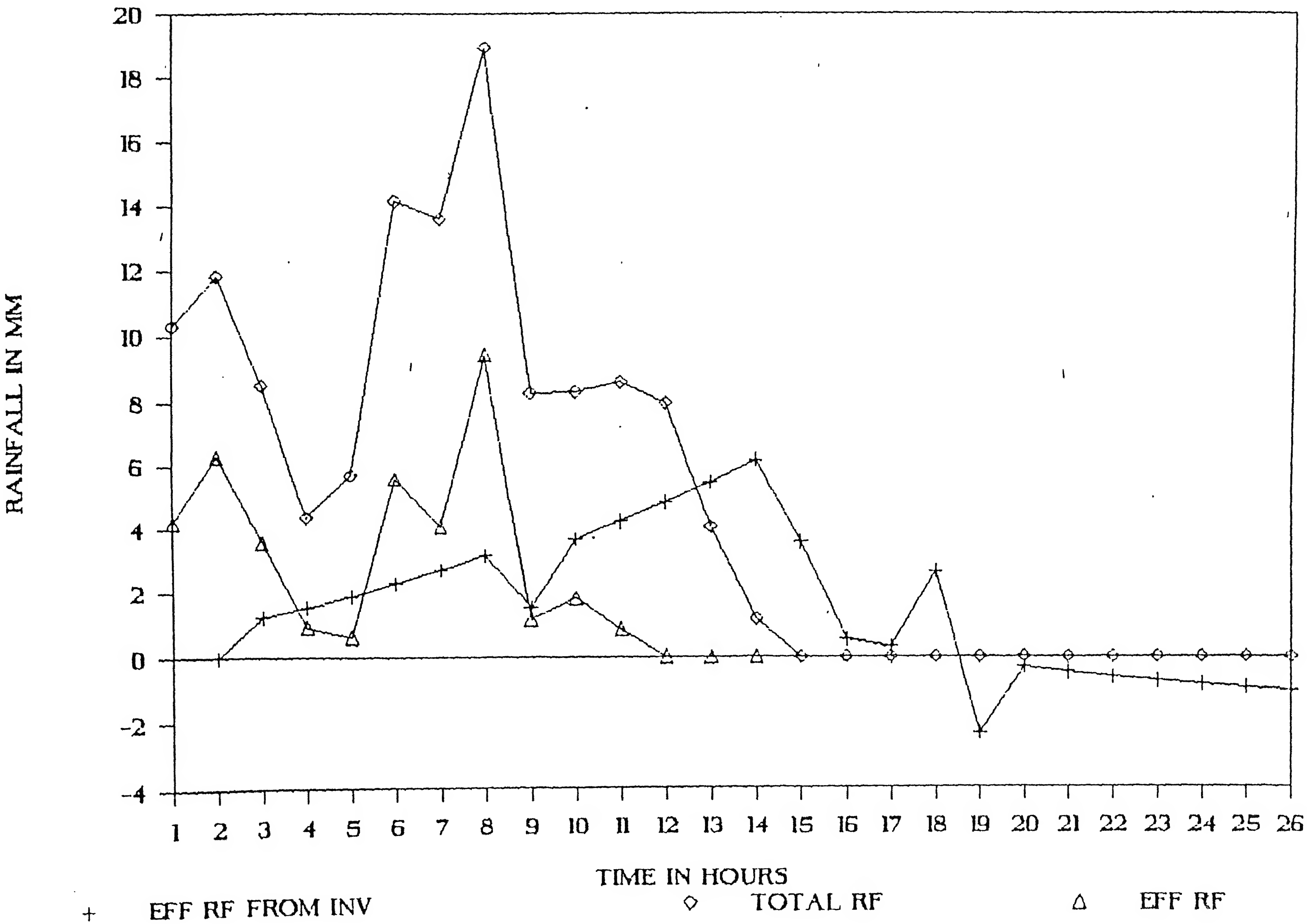


TABLE 4.6 DSRO, effective rainfall and their cumulative values, unit hydrograph values

VALUES AFTER ITERATION 1

Q(I)	SUMQ(I)	UINV(I)	U(I)	X(I)	SUMX(I)
.ØØØØE+ØØ	.ØØØØE+ØØ	.6264E+Ø1	.1596E+ØØ	.ØØØØE+ØØ	.ØØØØE+ØØ
.ØØØØE+ØØ	.ØØØØE+ØØ	-.5263E+Ø1	.1341E+ØØ	.ØØØØE+ØØ	.ØØØØE+ØØ
.1958E+ØØ	.1958E+ØØ	.ØØØØE+ØØ	.1127E+ØØ	.1227E+Ø1	.1227E+Ø1
.4126E+ØØ	.6Ø84E+ØØ	.ØØØØE+ØØ	.947ØE-Ø1	.1553E+Ø1	.278ØE+Ø1
.652ØE+ØØ	.126ØE+Ø1	.ØØØØE+ØØ	.7957E-Ø1	.1912E+Ø1	.4693E+Ø1
.9158E+ØØ	.2176E+Ø1	.ØØØØE+ØØ	.6685E-Ø1	.23Ø5E+Ø1	.6998E+Ø1
.12Ø6E+Ø1	.3382E+Ø1	.ØØØØE+ØØ	.5617E-Ø1	.2734E+Ø1	.9732E+Ø1
.1524E+Ø1	.49Ø6E+Ø1	.ØØØØE+ØØ	.472ØE-Ø1	.3198E+Ø1	.1293E+Ø2
.1524E+Ø1	.643ØE+Ø1	.ØØØØE+ØØ	.3966E-Ø1	.1527E+Ø1	.1446E+Ø2
.1872E+Ø1	.83Ø2E+Ø1	.ØØØØE+ØØ	.3332E-Ø1	.37Ø4E+Ø1	.1816E+Ø2
.2252E+Ø1	.1Ø55E+Ø2	.ØØØØE+ØØ	.28ØØE-Ø1	.4255E+Ø1	.2242E+Ø2
.2667E+Ø1	.1322E+Ø2	.ØØØØE+ØØ	.2352E-Ø1	.4852E+Ø1	.2727E+Ø2
.3118E+Ø1	.1634E+Ø2	.ØØØØE+ØØ	.1976E-Ø1	.5492E+Ø1	.3276E+Ø2
.36Ø8E+Ø1	.1995E+Ø2	.ØØØØE+ØØ	.1661E-Ø1	.6189E+Ø1	.3895E+Ø2
.36Ø8E+Ø1	.2355E+Ø2	.ØØØØE+ØØ	.1395E-Ø1	.3611E+Ø1	.4256E+Ø2
.3118E+Ø1	.2667E+Ø2	.ØØØØE+ØØ	.1172E-Ø1	.5416E+ØØ	.431ØE+Ø2
.2667E+Ø1	.2934E+Ø2	.ØØØØE+ØØ	.985ØE-Ø2	.297ØE+ØØ	.434ØE+Ø2
.2667E+Ø1	.32Ø1E+Ø2	.ØØØØE+ØØ	.8276E-Ø2	.2669E+Ø1	.46Ø7E+Ø2
.1872E+Ø1	.3388E+Ø2	.ØØØØE+ØØ	.6954E-Ø2	-.231ØE+Ø1	.4376E+Ø2
.1524E+Ø1	.354ØE+Ø2	.ØØØØE+ØØ	.5843E-Ø2	-.3Ø47E+ØØ	.4345E+Ø2
.12Ø6E+Ø1	.3661E+Ø2	.ØØØØE+ØØ	.49Ø9E-Ø2	-.4679E+ØØ	.4298E+Ø2
.9158E+ØØ	.3752E+Ø2	.ØØØØE+ØØ	.4125E-Ø2	-.61Ø5E+ØØ	.4237E+Ø2
.652ØE+ØØ	.3818E+Ø2	.ØØØØE+ØØ	.3466E-Ø2	-.7363E+ØØ	.4164E+Ø2
.4126E+ØØ	.3859E+Ø2	.ØØØØE+ØØ	.2912E-Ø2	-.847ØE+ØØ	.4Ø79E+Ø2
.1958E+ØØ	.3878E+Ø2	.ØØØØE+ØØ	.2447E-Ø2	-.9446E+ØØ	.3985E+Ø2
.ØØØØE+ØØ	.3878E+Ø2	.ØØØØE+ØØ	.2Ø56E-Ø2	-.1Ø31E+Ø1	.3882E+Ø2

TABLE 4.6(Contd.)
(Rainfall, storage, abstractions and their cumulative values)

P(I)	SUMP(I)	S(I)	SUMS(I)	EBS(I)	SUMEBS(I)
.1032E+02	.1032E+02	.0000E+00	.0000E+00	.1032E+02	.1032E+02
.1185E+02	.2217E+02	.0000E+00	.0000E+00	.1185E+02	.2217E+02
.8550E+01	.3072E+02	.1031E+01	.1031E+01	.7323E+01	.2949E+02
.4370E+01	.3509E+02	.1141E+01	.2172E+01	.2817E+01	.3231E+02
.5720E+01	.4081E+02	.1260E+01	.3432E+01	.3808E+01	.3612E+02
.1419E+02	.5500E+02	.1390E+01	.4822E+01	.1188E+02	.4800E+02
.1365E+02	.6865E+02	.1528E+01	.6350E+01	.1092E+02	.5892E+02
.1891E+02	.8756E+02	.1674E+01	.8024E+01	.1571E+02	.7463E+02
.8320E+01	.9588E+02	.3154E-02	.8027E+01	.6793E+01	.8142E+02
.8370E+01	.1043E+03	.1832E+01	.9859E+01	.4666E+01	.8609E+02
.8660E+01	.1129E+03	.2003E+01	.1186E+02	.4405E+01	.9049E+02
.8020E+01	.1209E+03	.2185E+01	.1405E+02	.3168E+01	.9366E+02
.4070E+01	.1250E+03	.2375E+01	.1642E+02	-.1422E+01	.9224E+02
.1170E+01	.1262E+03	.2582E+01	.1900E+02	-.5019E+01	.8722E+02
.0000E+00	.1262E+03	.2979E-02	.1901E+02	-.3611E+01	.8361E+02
.0000E+00	.1262E+03	-.2576E+01	.1643E+02	-.5416E+00	.8307E+02
.0000E+00	.1262E+03	-.2370E+01	.1406E+02	-.2970E+00	.8277E+02
.0000E+00	.1262E+03	.2203E-02	.1406E+02	-.2669E+01	.8010E+02
.0000E+00	.1262E+03	-.4182E+01	.9880E+01	.2310E+01	.8241E+02
.0000E+00	.1262E+03	-.1829E+01	.8051E+01	.3047E+00	.8272E+02
.0000E+00	.1262E+03	-.1674E+01	.6377E+01	.4679E+00	.8319E+02
.0000E+00	.1262E+03	-.1526E+01	.4851E+01	.6105E+00	.8380E+02
.0000E+00	.1262E+03	-.1388E+01	.3463E+01	.7363E+00	.8453E+02
.0000E+00	.1262E+03	-.1260E+01	.2203E+01	.8470E+00	.8538E+02
.0000E+00	.1262E+03	-.1140E+01	.1063E+01	.9446E+00	.8632E+02
.0000E+00	.1262E+03	-.1031E+01	.3203E-01	.1031E+01	.8735E+02

not only during the storms but also afterwards which is realistic. So inverse model gives better estimate.

4.5.4 CONCLUSION

A menu based interactive computer program for UH analysis has been successfully implemented. The problems used to illustrate the capability of interactive programs show that an interactive menu based programs are easy to use, particularly for the use of different alternative approaches in the various steps of analysis and design, and further more facilitates intermediate graphic output in taking decision about the suitablity of the approach used.

CHAPTER 5

SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FUTURE WORK

5.1 SUMMARY

A computer program has a number of steps and one may have to use them iteratively, so interactive programs are more useful, powerful and user-friendly. There are various interaction styles. Menu selection is one of them. Menu selection systems are attractive because they can eliminate training and memorisation of complex command sequences. Menu selection applications range from trivial choices between two items to complex videotex systems. Pop-up or pull down menus appear on the screen in response to a click with the pointing device such as a mouse. Mouse is used to select the options given in the menu.

Truemouse is a software developed for use with PC mouse or microsoft mouse. Truemouse was developed to enhance the basic mouse functions.

An approach to menu based interactive programs in Hydrology and Water Resources is illustrated with two examples using Truemouse software. In the present study, frequency analysis and Unit Hydrograph analysis programs have been developed to illustrate the use of Truemouse software. Various menus are developed to perform the various program steps. The software is found to be very much useful in performing various steps involved in the execution of the program.

5.2 Conclusions

Interactive menu based program is shown to be easy to use, versatile and user-friendly. The two programs developed, demonstrate the use of menu based interactive programming with mouse.

5.3 Suggestions for future work

In the present study, two prgrams are developed to demonstrate the use of menu based interactive programing in Hydrology and Water Resources. Several other programs available in this area can also be changed into menu based interactive programs to make them easy to use and user-friendly.

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NOTHING: Indicates that no action is taken.
An alternative to the EXECUTE, TYPE,
and MATCH statements.

B. Statement Format

Statement consists of 4 elements: Label, Command, Parameter and comments. The statement format is

[label:] command parameters [;comments]

** Note: The elements in bracket "[ ]" are optional elements, which can be with or without in a statement.

Label: A label is the name you assign to a statement, which allows the program to execute statements in a different order as they appear in source file.

* Label must be followed by a colon(:)
* At least one space between the colon and command.
* Do not use command names or reserved words... BACKSPACE ENTER, ESC, TAB for labels.

Parameters: Menu programming language uses three types of parameters:

numeric parameters.
string parameters.
attribute parameters.

* Numeric parameters: used for numeric data, such as screen coordinates or movement-sensitivity values for the mouse.
* String parameters: string parameters specify text for menus or messages.
* Display attribute parameters: A display attribute parameter specifies what color a menu or message box appears on the screen.

Display attribute = Foreground colors + Background colors.

Color	Foreground	Background
Black	Ø	Ø
Blue	1	16
Green	2	32
Cyan (blue-green)	3	48
Red	4	64
Magenta	5	8Ø
Brown	6	96
White	7	112
Gray	8	128
Light Blue	9	144
Light Green	1Ø	16Ø
Light Cyan	11	176
Light Red	12	192
Light Magenta	13	2Ø8
Yellow	14	224
White (high intensity)	15	24Ø

Comments: Comments describe what a statement does, which have no effect when the statement is executed.

There are five types of statements in the menu language:

1. Event statements: BEGIN, ASSIGN
   Define what action is taken when a mouse event occurs.

2. Menu statements: MENU, OPTION, MEND
   Create single-column menus.

3. Popup statements: POPUP, TEXT, SELECT, PEND
   Create multiple-column menus and message boxes.

4. Action statements: EXECUTE, TYPE, NOTHING
   Perform an action as a result of a mouse event, menu subroutine, or string match statement.

5. String match statement: MATCH
   Executes other statements depending on what is displayed on the screen.

C. Command description

1. BEGIN

[SYNTAX]

```
BEGIN    [lfbtn], [rtbtn], [mdbtn],
         [lfmov], [rtmov], [upmov],
         [dnmov], [hsen], [vsen]
```

Begin statement specifies 9 parameters(these parameters to be defined strictly in accordance with above sequence). Each parameter defines a statement to be executed when the user clicks a mouse button or moves the mouse. There are three types of parameters in the BEGIN statement:

Button parameters:

lfbtn	Left button clicking
rtbtn	Right button clicking
mdbtn	Middle button clicking

Define the action taken when one of mouse buttons are clicked.

Movement parameters:

lfmov	Move leftword
rtmov	Move rightword
upmov	Move upword
dnmov	Move downward

Define the action taken when the mouse is moved.

Movement sensitivity parameters:

hsen	Horizontal movement sensitivity
vsen	vertical movement sensitivity

Example:

```
BEGIN ent, esc,, lf, rt, up, dn

lf: TYPE Ø,75      ;simulate the left cursor key
rt: TYPE Ø,77      ;simulate the right cursor key
up: TYPE Ø,72      ;simulate the up cursor key
dn: TYPE Ø,8Ø      ;simulate the down cursor key
esc:TYPE ESC       ;simulate the Esc key
ent:TYPE ENTER     ;simulate the enter key
```

ent: Define left button statement.
esc: Define right button statement.
lf: Define move leftword statement.
rt: Define move rightword statement.
up: Define move upward statement.

C. Command description

1. BEGIN

[SYNTAX]

```
BEGIN    [lfbtn], [rtbtn], [mdbtn],
         [lfmov], [rtmov], [upmov],
         [dnmov], [hsen], [vsen]
```

Begin statement specifies 9 parameters(these parameters to be defined strictly in accordance with above sequence). Each parameter defines a statement to be executed when the user clicks a mouse button or moves the mouse. There are three types of parameters in the BEGIN statement:

Button parameters:

lfbtn	Left button clicking
rtbtn	Right button clicking
mdbtn	Middle button clicking

Define the action taken when one of mouse buttons are clicked.

Movement parameters:

lfmov	Move leftword
rtmov	Move rightword
upmov	Move upword
dnmov	Move downward

Define the action taken when the mouse is moved.

Movement sensitivity parameters:

hsen	Horizontal movement sensitivity
vsen	vertical movement sensitivity

Example:

```
BEGIN ent, esc,, lf, rt, up, dn

lf: TYPE Ø,75       ;simulate the left cursor key
rt: TYPE Ø,77       ;simulate the right cursor key
up: TYPE Ø,72       ;simulate the up cursor key
dn: TYPE Ø,8Ø       ;simulate the down cursor key
esc:TYPE ESC        ;simulate the Esc key
ent:TYPE ENTER      ;simulate the enter key
```

ent: Define left button statement.
esc: Define right button statement.
lf: Define move leftword statement.
rt: Define move rightword statement.
up: Define move upward statement.
dn: Define move downward statement.

The BEGIN statement in this example gives initial values for all parameters except "mdbtn", "hsen", and "vsen". Because "mdbtn" isn't specified, nothing happens when the user clicks middle button. Because no values are given for "hsen" and "vsen", the default values are used (8 and 16 mickeys, respectively)

2. ASSIGN

[SYNTAX]

```
label:   ASSIGN [lfbtn], [rtbtn], [mdbtn],
         [lfmov], [rtmov], [upmov],
         [dnmov], [hsen], [vsen]
```

Assign statement used to redefine one or more parameters given in the Begin statement or most recent Assign statement. If a parameter value isn't specified in an ASSIGN statement then this particular parameter value will remain the same as BEGIN statement or last ASSIGN statement.

All parameters are defined in same format as Begin statement. All assign statements must be captioned with a label.

Example:

```
BEGIN  esc, ent, mml, lf, rt, up, dn
         .
         .
         .
reassign: ASSIGN y, not,,,, not, not 16, 18
```

In this example, the BEGIN statement assigns the initial values of all button and movement parameters. Because no values are specified for the sensitivity parameters ("vsen" and "hsen"), the default values are used.
The ASSIGN statement changes the values of the left button, right button, and up and down movement parameters. It also changes the value of "hsen" to 16 and the value of "vsen" to 18. Commas are used for the parameters whose values aren't changed.

3. EXECUTE

[SYNTAX]

```
ELabel: EXECUTE label [,label....]
```

Execute command is used to define other statements to be executed. Statements within an EXECUTE statement are executed sequentially starting with the first statement.

Parameters

Elabel	Name of the EXECUTE statement. All EXECUTE statements must be labeled.
label	Name of the statement to be executed.

Example:

```
exec:   EXECUTE dir, s, c, ent


dir:    TYPE "dir"
S :     TYPE 32        ; Space Code
C :     TYPE "c:"
ent:    TYPE enter
```

The EXECUTE statement labeled "exec" executes the statements labeled "dir", "s", "c", nd "ent". These statements simulate typing dir C: and pressing ENTER.

4. MATCH

[SYNTAX]

label: MATCH row, column, attribute, string, mlabel, nlabel

MATCH command is used to define a specified string in a given screen location. If it is found then execute the match statement, else execute the nomatch statement. Row, column are used to describe the absolute screen coordinates. The starting coordinates for the screen are in the upper-left corner of screen (row=1, column=1).

Parameters

label	Name of the MATCH statement. All MATCH statements must be labeled.
row,column	Used to specify the string coordinates on the screen.
attribute	Used to specify the attribute of string. This can be one of the symbolic values "normal", "bold", or "inverse", or a decimal value that denotes specific foreground and background colors.(refer to attribute parameters value)
string	This can be any string of up to 8Ø ASCII characters enclosed in double quotation marks (" ").
mlabel	if the string is matched, this label specifies statement will be executed.

nlabel   if the string is not matched, this label specifies statement will be executed.

Example:

```
BEGIN  leftb

leftb:      MATCH  5, 4Ø, normal, "test", find, not-find
find:       TYPE "string match"
not-find:   TYPE "string not match"
```

When user clicks the left mouse button, if there is a string "test", which on the screen at locate row=5, column=4Ø, and attribute=normal, then will print out a message " string match", else print out "string not match".

5. MENU

[SYNTAX]

```
label:  MENU "title", row, column, attribute
        OPTION "text", pointer
        .
        .
        .
        MEND
```

MENU statement used to create single-column Popup menus. When this statement is active, there will be a single-column menu display on the screen, The user chooses items in the menu by moving mouse cursor to the desired item. then clicking left mouse button at once, the equivalent statement specified by pointer of OPTION statement will be executed.

OPTION statement is used to define each menu item in the MENU statement.

Parameter

label	Name of the Menu subroutine. All Menu subroutines must be labeled.
title	Text of the menu title, enclosed in double quotation marks (" ").
row,column	Used to specify the top-left corner of the menu appears.
attribute	Used to specify the attribute of menu displayed on the screen.
text	Legend text for the menu item. The legend text must be enclosed in double quotation marks (" ").
pointer	Label of the statement will be executed when user chooses the menu item.

6. POPUP

[SYNTAX]

```
label:  POPUP row, column, attribute
        TEXT    "string"
        .
        .
        SELECT srow, scolumn, width, pointer
        .
        .
        .
        PEND
```

Popup statement is used to define multiple-column menu which are used in the same way as menu statement. Select command is used to define the selection area of items on the menu, and the statement which will be executed when the item is selected. Text command is used to define the menu title and the legend text for menu items.

Parameter

label	Name of the Popup subroutine. All Popup statements must be labeled.
row,column	Used to specify the top-left corner of menu on the screen (the top left corner on the screen is row 1, column 1).
attribute	A value that specifies how the menu is displayed on the screen. This can be "normal", "bold", or "inverse", or a decimal value that specifies particular foreground and background colors.
string	Defines the Popup menu title or the legend text of a menu item. All text must be enclosed in double quotation marks (" "). You can use ASCII code to construct lines and boxes. All string defined by text statement must be equal length.

Srow   defines the vertical starting point of item, selection area. Which is relative to the row coordinates specified in this Popup statements. Minimum value is 1.

Scolumn   defines the horizontal starting point of item selection area. Which is relative to the column coordinates specified in this Popup statements. Minimum value is 1.

Width   defines the width of item selection area.

Pointer   label of the statement to be executed, when the item selection area is chosen in the menu.

7. TYPE

[SYNTAX]
label : TYPE key [, key ...]

TYPE statement simulates typing keystrokes. All keys specified in the TYPE statement are inserted into a keyboard buffer when the menu program is running and are not output as keystrokes until the menu program becomes inactive.

Parameter

label   Name of the TYPE statement. All TYPE statements must be labeled.

key   Name of the key. It can be:

* A single letter or number enclosed in double quotation marks (" "); or a sequence of keystrokes enclosed in double quotation marks (such as "dir")

* A standard ASCII code (characters Ø through 127), or an extended ASCII code (characters 128 through 255)
* An extended keyboard scan code

* Any of the following predefined symbolic keys: "enter", "tab", "backsp", "esc".

ASCII Control Character

ASCII code	Key equivalent	ASCII code	Key equivalent
0	none	16	CONTROL-P
1	CONTROL-A	17	CONTROL-Q
2	CONTROL-B	18	CONTROL-R
3	CONTROL-C	19	CONTROL-S
4	CONTROL-D	20	CONTROL-T
5	CONTROL-E	21	CONTROL-U
6	CONTROL-F	22	CONTROL-V
7	CONTROL-G	23	CONTROL-W
8	backspace	24	CONTROL-X
9	horizontal tab	25	CONTROL-Y
10	line feed	26	CONTROL-Z
11	CONTROL-K	27	ESCAPE
12	CONTROL-L	28	CONTROL-
13	carriage return	29	CONTROL-]
14	CONTROL-N	30	CONTROL-^
15	CONTROL-O	31	CONTROL-_

Extended Keyboard Scan Codes

Keystroke(s)	Scan code
HOME	0, 71
CONTROL-HOME	0, 119
up arrow key	0, 72
down arrow key	0, 80
left arrow key	0, 75
CONTROL-left arrow key	0, 115
right arrow key	0, 77
CONTROL-right arrow key	0, 116
END	0, 79
CONTROL-END	0, 117
PAGEUP	0, 73
CONTROL-PAGEUP	0, 132
PAGEDOWN	0, 81
CONTROL-PAGEDOWN	0, 118

CONTROL-PRINTSCREEN	Ø, 114
INSERT	Ø, 82
DELETE	Ø, 83
SHIFT-TAB	Ø, 15

Keystroke(s)	Scan code	Keystroke(s)	Scan code
F1	Ø,59	ALT-Ø	Ø,129
F2	Ø,6Ø	ALT-1	Ø,12Ø
F3	Ø,61	ALT-2	Ø,121
F4	Ø,62	ALT-3	Ø,122
F5	Ø,63	ALT-4	Ø,123
F6	Ø,64	ALT-5	Ø,124
F7	Ø,65	ALT-6	Ø,125
F8	Ø,66	ALT-7	Ø,126
F9	Ø,67	ALT-8	Ø,127
F1Ø	Ø,68	ALT-9	Ø,128
SHIFT-F1	Ø,84	ALT--	Ø,13Ø
SHIFT-F2	Ø,85	ALT-=	Ø,131
SHIFT-F3	Ø,86	ALT-A	Ø, 3Ø
SHIFT-F4	Ø,87	ALT-B	Ø, 48
SHIFT-F5	Ø,88	ALT-C	Ø, 46
SHIFT-F6	Ø,89	ALT-D	Ø, 32
SHIFT-F7	Ø,9Ø	ALT-E	Ø, 18
SHIFT-F8	Ø,91	ALT-F	Ø, 33
SHIFT-F9	Ø,92	ALT-G	Ø, 34
SHIFT-F1Ø	Ø,93	ALT-H	Ø, 35

Keystroke(s)	Scan code	Keystroke(s)	Scan code
CONTROL-F1	Ø, 94	ALT-I	Ø,23
CONTROL-F2	Ø, 95	ALT-J	Ø,36
CONTROL-F3	Ø, 96	ALT-K	Ø,37
CONTROL-F4	Ø, 97	ALT-L	Ø,38
CONTROL-F5	Ø, 98	ALT-M	Ø,5Ø
CONTROL-F6	Ø, 99	ALT-N	Ø,49
CONTROL-F7	Ø,1ØØ	ALT-O	Ø,24
CONTROL-F8	Ø,1Ø1	ALT-P	Ø,25
CONTROL-F9	Ø,1Ø2	ALT-Q	Ø,16
CONTROL-F1Ø	Ø,1Ø3	ALT-R	Ø,19

ALT-F1	Ø,1Ø4	ALT-S	Ø,31
ALT-F2	Ø,1Ø5	ALT-T	Ø,2Ø
ALT-F3	Ø,1Ø6	ALT-U	Ø,22
ALT-F4	Ø,1Ø7	ALT-V	Ø,47
ALT-F5	Ø,1Ø8	ALT-W	Ø,17
ALT-F6	Ø,1Ø9	ALT-X	Ø,45
ALT-F7	Ø,11Ø	ALT-Y	Ø,21
ALT-F8	Ø,111	ALT-Z	Ø,44
ALT-F9	Ø,112		
ALT-F1Ø	Ø,113		

ERROR MESSAGES

Command: (ASSIGN) defined label not found

Label defines in ASSIGN statement, which is not defined in source file.

Command: (ASSIGN) parameter define too much

ASSIGN statement maximun can define 9 parameters.

Command: (BEGIN) not found

The source file doesn't define BEGIN statement.

Command: (BEGIN) define label not found

Label defines in BEGIN statement, which is not defined in source file.

Command: (BEGIN) define parameter too much

BEGIN statement maximun can define 9 parameters.

Command: (EXECUTE) define label = xxxx not found

Label defined in EXECUTE statement, which was not define in the source file

Command: (MENU) parameter error

MENU statement must define 3 parameters: ROW, COLUMN, ATTRIBUTE.

Command: (MENU) attribute value error

Attribute value: Ø < attribute value < 255.

Command: (MENU) Must include at least one OPTION statement

MENU subroutine must include at least one OPTION statement.

Command: (MENU) define label = xxx not found

Label defines in the OPTION statement, which isn't found in source file.

Command: (OPTION) didn't define label

OPTION statement must defines a label.

Command: (MATCH) parameter error

MATCH statement must define 6 parameters. Which are 'ROW', 'COLUMN', 'ATTRIBUTE', 'STRING', 'MATCH' , 'NOMATCH'.

MACTCH and NOMATCH are label.

Command: (MATCH) define label not found

Label defines in the MACTH statement isn't defined in the source file.

Command: (POPUP) parameter error

In the POPUP statement must define 3 parameter, which are 'ROW', 'COLUMN', 'ATTRIBUTE'.

Command: (POPUP) must include at least one SELECT statement

In the POPUP subroutine must include at least one SELECT statement.

Command: (TEXT) string length non equal

All string defined by TEXT statement in the POPUP subroutine must be equal length.

Command: (SELECT) didn't define label

All SELECT must define label.

1. MENU MAKING PROGRAM FOR FREQUENCY ANALYSIS

```
BEGIN    lbtn, rbtn, mbtn, lmov, rmov, umov, dmov,1,25

lbtn:     TYPE      13
mbtn:     TYPE      27
lmov:     TYPE      Ø,75
rmov:     TYPE      Ø,77
umov:     TYPE      Ø,72
dmov:     TYPE      Ø,8Ø
rbtn:     menu      "         MAIN MENU       ",12,4Ø,21
          option     " DIR             ",main71
          option     " INSTRUCTIONS",main6
          option     " PROBABILITY DISTRIBUTIONS ",main8
          option     " MOUSE HELP",main7
          option     " RUN FREQ",main9
          option     " QUIT ",main1Ø
          mend
main71:   menu     "         DIRECTORY              ",12,4Ø,21
          option   "           A     ",main72
          option   "           C_    ",main73
          option   " C:\CMP\FORTRAN ",main74
          option   " C:\USER\RAMESH ",main75
          option   " C:\TRUMOUSE     ",main76
          option   " MAIN MENU       ",rbtn
          mend
main6:    popup     8,2Ø,21
          TEXT     "7============== INSTRUCTIONS ====================9"
          TEXT     "|IF YOU WANT YOUR RESULTS TO COME IN NEW FILE     |"
          TEXT     "|THEN YOU HAVE TO RENAME YOUR FIRST OUTPUT FILE   |"
          TEXT     "|OTHERWISE ALL RESULTS WILL COME IN SINGLE FILE   |"
          TEXT     "1=================================================3"
          SELECT    1,16,14,NUL
          PEND
main7:    popup     8,2Ø,21
          text     "7========  MOUSE HELP MENU  ========9"
          text     "|THIS SAMPLE IS USED UNDER FAP PROG |"
          text     "|FOLLOWING ARE THE KEY DEFINITIONS  |"
          text     "4-----------------------------------6"
          text     "|LEFT BUTTON -- ENTER KEY           |"
          text     "4-----------------------------------6"
          text     "|MIDDLE BUTTON -- ESC KEY           |"
          text     "4-----------------------------------6"
          text     "|RIGHT BUTTON -- MOUSE MENU DISPLAY |"
          text     "1===================================3"
          SELECT    1,1Ø,19,NUL
          pend
main8:    popup     1Ø,1Ø,21
          TEXT     "7========================POP-UP MENU===========================
          TEXT     "|DISTRIBUTION TYPE            OUTPUT FILES        VIEW OUTPUT FILES
          TEXT     "|NORMAL DISTRIBUTION_          NORMD.OUT              NORMD.OUT
          TEXT     "|INVERSE PEARSON TRANS         INPDS.OUT              INPDS.OUT
          TEXT     "|SQUAREROOT TRANS              SQRTE.OUT              SQRTE.OUT
          TEXT     "|LOG NORMAL DIS(MLE)           LOGNR.OUT              LOGNR.OUT
          TEXT     "|PEARSION DISTRIBUTION         PEARS.OUT              PEARS.OUT
          TEXT     "|LOG TRANSFORMATION(MOM)       LOGTR.OUT              LOGTR.OUT
          TEXT     "4-------------------------------------------------------------
```

2. MENU MAKING PROGRAM FOR UNIT HYDROGRAPH


```
BEGIN lbtn, rbtn, mbtn, lmov, rmov, umov, dmov,1,25

lbtn:   TYPE    13
mbtn:   TYPE    27
lmov:   TYPE    Ø,75
rmov:   TYPE    Ø,77
umov:   TYPE    Ø,72
dmov:   TYPE    Ø,8Ø
rbtn:   menu    "        MAIN MENU     ",12,4Ø,21
        option  " DIR           ",main71
        option  " DATA INPUT ",main1
        option  " FILES",main2
        option  " PRELIMINARY ANALYSIS",main3
        option  " UNIT HYDROGRAPH METHODS",main4
        option  " GRAPHS",main6
        option  " QUIT",main7
        mend
main71: menu    "       DIRECTORY             ",12,4Ø,21
        option  "         A    ",main72
        option  "         C    ",main73
        option  " C:\CMP\FORTRAN ",main74
        option  " C:\USER\RAMESH ",main75
        option  " C:\TRUMOUSE     ",main76
        option  " MAIN MENU       ",rbtn
        mend
main1:  menu    "           INPUT TYPE       ",12,3Ø,37
        option  " EFF RAINFALL AND DSRO VALUES ",main4
        option  " TOTAL RAINFALL AND DIS VALUES",main3
        option  " STAGE.RATING CURVE & RAINFALL VALUES",main1Ø
        option  " MAIN MENU",rbtn
        mend
main2:  menu    "      FILES             ",12,4Ø,1Ø
        option  "        RETRIEVE      ",main13
        option  "        PRINT         ",main14
        option  "        MAIN MENU     ",rbtn
        mend
main3:  menu    "           PRE ANALYSIS ",12,4Ø,44
        option  "  EFF RAINFALL AND DSRO SEPARATION",main16
        option  "  DSRO SEPARATION         ",main17
        option  "  MAIN MENU",rbtn
        mend
main4:  menu    "UNIT HYDROGRAPH METHODS",12,4Ø,116
        option  "  EXACT METHOD",main19
        option  "  APPROXIMATE METHODS",main2Ø
        option  "  CONCEPTUAL MODELS ",main21
        option  "  INVERSE SYSTEM MODELLING",main22
        option  "  MAIN MENU",rbtn
        mend
main16: menu    "  SEPARATION METHODS ",12,4Ø,14
        option  "  PHI INDEX METHOD  ",main51
        option  "  HORTON'S METHOD   ",main52
        option  "  CORPS OF ENGGS METHOD ",main53
        option  "  MAIN MENU ",rbtn
        mend
```

```
main19: menu    "  EXACT METHOD",12,40,14
        option  " MATRIX INVERSION",main24
        option  " UNIT HYDROGRAPH METHODS",main4
        option  " MAIN MENU      ",rbtn
        mend
main20: menu    " APPROXIMATE METHODS",12,40,120
        option  " METHOD OF LEAST SQUARES",main25
        option  " CUT-OFF FREQ IN TRANS METHOD",main26
        option  " UNIT HYDROGRAPH METHODS",main4
        option  " MAIN MENU ",rbtn
        mend
main21: menu    " CONCEPTUAL MODELS",12,40,79
        option  " METHOD OF MOMENTS",main27
        option  " METHOD OF LEAST SQUARES",main28
        option  " UNIT HYDROGRAPH METHODS",main4
        option  " MAIN MENU",rbtn
        mend
main27: menu    " METHOD OF MOMENTS PROCEDURE",12,40,36
        option  " 2-PARAMETER NASH MODEL",main29
        option  " 3-PARAMETER NASH MODEL",main30
        option  " CONCEPTUAL MODELS ",main21
        option  " UNIT HYDROGRAPH METHODS",main4
        option  " MAIN MENU           ",rbtn
        mend
main28: menu    " METHOD OF LEAST SQUARES PR",12,40,117
        option  " 2-PARAMETER NASH MODEL",main31
        option  " 3-PARAMETER NASH MODEL",main32
        option  " CONCEPTUAL MODELS ",main21
        option  " UNIT HYDROGRAPH METHODS",main4
        option  " MAIN MENU             ",rbtn
        mend
main22: menu    " INVERSE SYSTEM MODELLING",12,40,13
        option  "  INVERSE MODEL ",main33
        option  "  UNIT HYDROGRAPH METHODS",main4
        option  "  MAIN MENU      ",rbtn
        mend
main34: TYPE "NOT IMPLEMENTED",13,10
main6:  TYPE "LOTUS",13,10
main7:  TYPE 27
main10: TYPE "RATING",13,10
main14: NOTHING
main17: TYPE "RUNSP",13,10
main24: TYPE "EX",13,10
main25: TYPE "MLS",13,10
main26: TYPE "NOT IMPLEMENTED",13,10
main29: TYPE "CONTI",13,10
main31: TYPE "NASHM",13,10
main32: TYPE "NOT IMPLEMENTED",13,10
main33: TYPE "INV",13,10
main51: TYPE "LOSS",13,10
main52: TYPE "NOT IMPLEMENTED",13,10
main53: TYPE "RFSEP",13,10
```

```
CONNUI: POPUP 1,1,79
        TEXT   "7=========================POPUP-C============================9"
        TEXT   "|    PROG.DAT              INPUT FILE FOR MATRIX INVERSION     |"
        TEXT   "|                          AND METHOD OF LEAST SQUARES         |"
        TEXT   "|    EX.FOR                MATRIX INVERSION METHOD             |"
        TEXT   "|    EX.OUT                OUTPUT  FILE                        |"
        TEXT   "|    MLS.FOR               METHOD OF LEAST SQUARES             |"
        TEXT   "|    MLS.OUT               OUTPUT FILE                         |"
        TEXT   "|    POPUP-A                                                   |"
        TEXT   "|    POPUP-B                                                   |"
        TEXT   "|    MAIN MENU                                                 |"
        TEXT   "1=============================================================3"

        SELECT 2,4,10,PROGD
        SELECT 4,4,10,EXF
        SELECT 5,4,10,EXO
        SELECT 6,4,10,MLSF
        SELECT 7,4,10,MLSO
        SELECT 8,4,10,main13
        SELECT 9,4,10,CONNU
        SELECT 10,4,12,rbtn
        PEND

CONF:   TYPE "SO CONTI.FOR",13,10
CONO:   TYPE "SO CONTI.OUT",13,10
NASHF:  TYPE "SO NASHCOE3.FOR",13,10
NASHD:  TYPE "SO NASHPRO.DAT",13,10
NASHO:  TYPE "SO NASHPRO.OUT",13,10
RESEPF: TYPE "SO RESEP.FOR",13,10
RESEPO: TYPE "SO RESEP.OUT",13,10
LOSSF:  TYPE "SO LOSS.FOR",13,10
LOSSO:  TYPE "SO LOSS.OUT",13,10
RF:     TYPE "SO RATING.FOR",13,10
RD:     TYPE "SO R.DAT",13,10
RO:     TYPE "SO R.OUT",13,10
GF:     TYPE "SO GAUGE.FOR",13,10
GD:     TYPE "SO GD.DAT",13,10
GO:     TYPE "SO NASHPRO.DAT",13,10
PROGD:  TYPE "SO PROG.DAT",13,10
EXF:    TYPE "SO EX.FOR",13,10
EXO:    TYPE "SO EX.OUT",13,10
MLSF:   TYPE "SO MLS.FOR",13,10
MLSO:   TYPE "SO MLS.OUT",13,10
main72: TYPE " A: ",13,10
main73: TYPE " CD\C: ",13,10
main74: TYPE " CD\CMP\FORTRAN",13,10
main75: TYPE " CD\USER\RAMESH",13,10
main76: TYPE " CD\TRUHOUSE",13,10
```

```
main13: popup 1,1,79
        TEXT   "7===========================POPUP-A===========================9"
        TEXT   "!              FILES                         DISCRIPTION        !"
        TEXT   "!    CONTI.FOR         NASH MODEL - ESTIMATION  OF N & K BY     !"
        TEXT   "!                      OPTIMISATION,COMPUTATION OF HYDROGRAPH,  !"
        TEXT   "!                      ERRORS AND CALIBRATION OF MODEL          !"
        TEXT   "!    CONTI.OUT         OUTPUT FILE                              !"
        TEXT   "!    NASHM.FOR         COMPUTATION OF HYDROGRAPHS, ERRORS  AND  !"
        TEXT   "!                      CALIBRATION OF MODEL                     !"
        TEXT   "!    NASHPRO.DAT       INPUT FILE                               !"
        TEXT   "!    NASHPRO.OUT    -  OUTPUT FILE                        -     !"
        TEXT   "!    MAIN MENU                                                  !"
        TEXT   "!                  CONTINUE                                     !"
        TEXT   "1==============================================================3"
        SELECT  3,4,12,CONF
        SELECT  6,4,12,CONO
        SELECT  7,4,15,NASHF
        SELECT  9,4,15,NASHD
        SELECT  10,4,15,NASHO
        SELECT  11,4,15,rbtn
        SELECT  12,15,10,CONNU
        PEND
CONNU:  POPUP 1,1,79
        TEXT   "7===========================POPUP-B===========================9"
        TEXT   "!    RFSEP.FOR            CORPS OF ENGRS METHOD OF RUNOFF AND  !"
        TEXT   "!                         RAINFALL SEPARATION                  !"
        TEXT   "!    RFSEP.OUT            OUTPUT FILE                          !"
        TEXT   "!    LOSS.FOR             PHI INDEX METHOD OF RUNOFF AND       !"
        TEXT   "!                         RAINFALL SEPARATION                  !"
        TEXT   "!    LOSS.OUT             OUTPUT FILE                          !"
        TEXT   "!    RATING.FOR           RATING CURVE PREPARATION             !"
        TEXT   "!    RATING.DAT           INPUT FILE                           !"
        TEXT   "!    RATING.OUT           OUTPUT FILE                          !"
        TEXT   "!    GAUGE.FOR            DISCHARGE FROM THE RATING CURVE      !"
        TEXT   "!    GD.DAT               INPUT FILE                           !"
        TEXT   "!    NASHPRO.DAT          OUTPUT FILE                          !"
        TEXT   "!    POPUP-A                                                   !"
        TEXT   "!    MAIN MENU                                                 !"
        TEXT   "!                  CONTINUE                                    !"
        TEXT   "1==============================================================3"

        SELECT  2,4,12,RFSEPF
        SELECT  4,4,12,RFSEPO
        SELECT  5,4,12,LOSSF
        SELECT  7,4,12,LOSSO
        SELECT  8,4,12,RF
        SELECT  9,4,12,RD
        SELECT  10,4,12,RO
        SELECT  11,4,12,GF
        SELECT  12,4,12,GD
        SELECT  13,4,12,GO
        SELECT  14,4,12,main13
        SELECT  15,4,12,rbtn
        SELECT  16,15,10,CONNUI
        PEND
```